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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 429

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

Washington, D. C. PROFESSIONAL PAPER February 28, 1917

LIFE HISTORY OF THE CODLING MOTH IN THE PECOS VALLEY NEW MEXICO

By

A. L. QUAINTANCE, Entomologist in Charge of Deciduous Fruit Insect Investigations, and E. W. GEYER, Scientific Assistant

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INTRODUCTION.

During the past four years the Bureau of Entomology has maintained a field laboratory at Roswell, N. Mex., for the purpose of investigating the life history and habits of the codling moth, *Carpocapsa pomonella* L., under semiarid conditions in the Southwest, and for the purpose of carrying out experiments in orchards for its control. Especial attention was given to the life history of the insect in that region during 1912 and 1913 in addition to extensive spraying operations in orchards. During 1914 and 1915 the work has been limited to orchard experiments.

The Pecos Valley, in the vicinity of Roswell, comprises an important fruit-growing section especially devoted to the cultivation of apples and pears. The codling moth in this region, due to the mild climate, is able to develop three and probably four broods of larvæ each season and is hence extremely injurious. The present investigation by the Bureau of Entomology will furnish needed information to the orchardists of the Pecos Valley in New Mexico for the control of the codling moth, and the results should be applicable to similar regions in the Southwest generally.

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This bulletin deals with the life history and habits of the codling moth, giving the results of observations in 1912 and 1913. Results of spraying operations during those years have been given in Bulletin No. 88 of this department. Subsequent experiments in orchards will be reserved for a later publication.

During the season of 1912 investigations were conducted by Mr. A. G. Hammar, assisted by Mr. E. R. Van Leeuwen. Mr. Hammar was also in charge of the work during 1913 and was assisted by Mr. L. L. Scott and the junior author. Messrs. R. J. Fiske and H. G. Ingerson rendered valuable assistance in connection with the preparation of the tables in the present paper. Owing to the death of Mr. Hammar it devolved upon the writers to prepare for publication the results of his studies and experiments.

DEFINITION OF TERMS USED.

The terms used herein are practically identical with those employed in recent former publications of the Bureau of Entomology on the codling moth. Thus the term "brood" is used in speaking of individuals of one generation of any stage, as egg, larva, or pupa. A "generation" is considered to begin with the egg stage and to terminate with the moth, or imago, stage of the same generation, thus including all the stages of the life cycle. The "complete life cycle" includes the time from the deposition of the egg of one generation to the time of deposition of the egg of the next generation.

Since the wintering larvæ of the codling moth in the Pecos Valley (as well as in other localities where there is even a partial second brood of larvæ) are from the different broods produced throughout the same season, they are referred to collectively as "wintering larvæ," and include all the larvæ which do not transform the same season as hatched.

Similarly, the overwintering larvæ when transformed in the spring to pupæ may be suitably referred to as "spring pupæ" and the resulting moths as "spring moths."

The terms used in designating the separate stages may be defined as follows:

Wintering larvæ may include larvæ of the first, second, third, and fourth broods of the preceding season.

The spring brood of pupæ include pupæ resulting from overwintering larvæ.

The spring brood of moths include moths emerging from the spring brood of pupæ.

The first generation includes:

The first brood of eggs;

The first brood of larvæ, which includes both transforming larvæ and wintering larvæ;

The first brood of pupæ, resulting from transforming larvæ;

The first brood of moths, which emerge from transforming pupæ of the same generation.

The second generation includes:
The second brood of eggs;
The second brood of larvæ, which includes both transforming larvæ and wintering larvæ;
The second brood of pupæ, resulting from transforming larvæ;
The second brood of moths, which emerge from pupæ of the same generation.
The third generation includes:
The third brood of eggs;
The third brood of larvæ, which includes both transforming larvæ and wintering larvæ;
The third brood of pupæ, resulting from the transforming larvæ;
The third brood of moths, which emerge from pupæ of the same generation.
The fourth generation (not complete) includes:
The fourth brood of eggs;
The fourth brood of larvæ; none of these larvæ transform until the following spring.

SEASONAL-HISTORY STUDIES OF 1912.

The rearing material in the spring of 1912 consisted of a considerable number of overwintering larvæ which had been collected at random in near-by orchards. About 500 larvæ were collected in January and early March, and later in March and in early April several thousand more were secured from the same source. Some 500 larvæ were transferred to "pupation sticks" (figs. 6, 7) for pupal observation, but the mortality among them was unduly high and many of them failed to withstand the transfer and reconstruction of cocoons. The overwintering larvæ in the spring were found in poor condition, many being small and feeble, and even in the field a number of dead ones were found in the cocoons.

A supply of larvæ was transferred from the field station at Douglas, Mich., both for the purpose of introducing the parasitic hymenopterous fly *Ascogaster carpocapsae* Vier., and to compare the time of emergence of the moths with specimens native to Roswell, N. Mex.—a point of interest in view of the frequent extensive shipment of larvæ into localities of variable conditions.

THE SPRING BROOD.

PUPATION OF SPRING BROOD.

The few observations taken on the pupal stage of the spring brood are not sufficient for conclusions as to the exact length of the pupal stage, nor the degree of variation in the spring brood of pupæ. The earliest pupa was found in the field March 15, and the earliest moth appeared in cages from field-collected material April 12, the pupation period being approximately 31 days. Fully 50 per cent of the insects were pupæ in the field by April 2, and on May 5 about one-half of the moths had emerged, which shows that the pupal stage for most individuals was about one month. The pupal stage during the latter half of the pupal period was much shorter. Records of seven individuals from March 22 to May 14, give an average of 24.4 days for the pupal stage.

EMERGENCE OF SPRING BROOD OF MOTHS.

The time for emergence of moths from Roswell-collected rearing material was contrasted with that brought from Douglas, Mich., and it was found that from the Roswell material moths emerged several days earlier than from material introduced from a more northern location, but were less regular in the number and time of appearance, although covering almost the same length of time. The Michigan moths showed a marked maximum of emergence about May 1; otherwise considerable similarity is noted. In this connection 542 moths were reared from the New Mexico material and 506 from the lot from Michigan. The records for emergence for the spring brood are given in Table I.[1]

TABLE I.—*Time of emergence of spring brood of codling moth, Roswell, N. Mex., in comparison with emergence of moths from material from Douglas, Mich., 1912. (See fig. 1.)*

Date of emergence.	Number of moths emerging.			Date of emergence.	Number of moths emerging.		
	Roswell.	Douglas.	Total.		Roswell.	Douglas.	Total.
Apr. 12	4	.....	4	May 7	36	28	64
13	1	.....	1	8	19	15	34
14	1	.....	1	9	28	12	40
15	0	.....	0	10	13	9	22
16	1	.....	1	11	12	9	21
17	5	.....	5	12	25	10	35
18	5	.....	5	13	23	16	39
19	4	.....	4	14	4	0	4
20	15	.....	15	15	5	0	5
21	13	.....	13	16	24	10	34
22	10	.....	10	17	12	4	16
23	12	1	13	18	14	6	20
24	26	2	28	19	8	6	14
25	27	4	31	20	8	3	11
26	26	6	32	21	8	5	13
27	13	4	17	22	4	0	4
28	8	15	23	23	2	2	4
29	11	36	47	24	0	.....	0
30	10	48	58	25	0	.....	0
May 1	32	46	78	26	2	.....	2
2	11	64	75	27	0	.....	0
3	11	62	73	28	1	.....	1
4	9	19	28				
5	16	27	43	Total	542	506	1,048
6	23	37	60				

EGG DEPOSITION OF SPRING BROOD OF MOTHS.

In order to secure deposition records on the spring brood, moths were confined in cages after the first emergence on April 21. From the 13 moths issuing in cage No. 1, bearing the above date of emergence, the first oviposition occurred April 25—four days later—and oviposition continued for a period of three days, the last deposition in cage No. 1 occurring April 28, seven days after emergence. The last oviposition recorded for the entire period covered by observations

[1] EXPLANATORY NOTE.—It may be well to explain here that each table in this publication should be considered a unit. Consecutive or successive tables are not necessarily continuations of the life history of the same individuals. For example, it will be noted that Table XIV is a record of the length of feeding period of 489 transforming larvæ of the second generation, while Table XVI includes observations on the length of the cocooning period of only 282 larvæ of this generation. Differences of this character may be due to natural or artificial causes, such as death of the insects, accidental injury, the removal of specimens for other purposes, etc.

occurred June 2. Hence the period of oviposition covered practically 38 days.

By a study of Table II it will be noted that the average number of days from the time of emergence to the time of first oviposition was 4.4 days; the maximum time 7 days, and the minimum time 2 days. The average duration of the oviposition period was 5.95 days; the

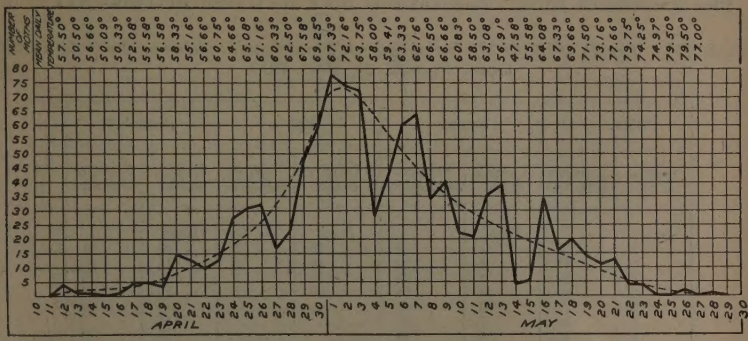

FIG. 1.—Emergence curve of the spring brood of the codling moth, Roswell, N. Mex., 1912. (Original.)

maximum 17 days, and the minimum 1 day. The average number of days from the date of moth emergence to the date of last oviposition was 10.39 days; the maximum, 21 days; and the minimum, 4 days.

TABLE II.—*Egg deposition of codling moths of the spring brood at Roswell, N. Mex., 1912.*

Cage No.	Number of moths.	Date of—			Number of days—		
		Emergence.	First oviposition.	Last oviposition.	Before first oviposition.	Of oviposition.	From date of emergence to last oviposition.
1	13	Apr. 21	Apr. 25	Apr. 28	4	3	7
2	10	22	27	29	5	2	7
3	12	23	28	30	5	2	7
4	26	24	26	30	2	4	6
5	27	25	29	.....	4	.....	.....
6	25	26	May 3	May 7	7	4	11
7	24	28	2	8	4	6	10
8	43	29	2	8	3	6	9
9	58	30	4	21	4	17	21
10	60	May 1	8	18	7	10	17
11	71	2	7	18	5	11	16
12	76	3	7	18	4	11	15
13	37	5	9	18	4	9	13
14	59	6	9	21	3	12	15
15	66	7	10	18	3	8	11
16	31	8	10	16	2	6	8
17	28	9	15	18	6	3	9
18	17	10	17	20	7	3	10
19	30	11	16	21	5	5	10
20	23	13	18	21	5	3	8
21	11	17	23	26	6	3	9
22	18	18	20	22	2	2	4
23	19	19	22	23	3	1	4
24	12	21	27	June 2	6	6	12
Average					4.4	5.95	10.39
Maximum					7	17	21
Minimum					2	1	4

LENGTH OF LIFE OF MOTHS.

Observations were made on the length of life of 335 male moths and 393 female moths. The average life of the male moths was 6.7 days; of the female 8.47 days. The maximum length of life of the male moth was 20 days and of the female 22 days. The minimum number of days for each sex was identical—2 days.

The records of these observations may be found in Table III.

TABLE III.—*Length of life of 728 individual male and female codling moths of the spring brood, Roswell, N. Mex., 1912.*

Male.		Female.		Male.		Female.	
Length of life.	Number of moths.	Length of life.	Number of moths.	Length of life.	Number of moths.	Length of life.	Number of moths.
Days.		*Days.*		*Days.*		*Days.*	
2	2	2	3	13	2	13	13
3	11	3	10	14	1	14	15
4	28	4	24	18	1	15	5
5	73	5	34	20	1	16	3
6	72	6	48	.....	.....	17	3
7	42	7	51	.....	.....	18	2
8	41	8	54	.....	.....	19	3
9	24	9	47	.....	.....	20	3
10	18	10	37	.....	.....	22	1
11	14	11	23				
12	5	12	14		335		393

Average length of life of male moths, 6.7 days.
Average length of life of female moths, 8.47 days.
Maximum length of life of male moths, 20 days.
Maximum length of life of female moths, 22 days.
Minimum length of life of male moths, 2 days.
Minimum length of life of female moths, 2 days.

THE FIRST GENERATION.

THE FIRST BROOD OF EGGS.

Length of incubation.—Observations on the length of incubation covered a period of one month, extending from April 26 until May 26, being the time when the eggs of this generation occurred in the field in greatest numbers.

The average length of time from the date of deposition until the appearance of the red ring was 4.2 days; the maximum, 7 days; the minimum, 2 days. The average length of the duration of the red ring was 2.47 days; the maximum, 5 days; minimum, 1 day. For the duration of the black spot is found an average of 2.36 days, while the maximum and minimum periods are identical with the corresponding periods of the red ring.

For the period of time covering the duration of incubation, or the time from date of deposition to date of hatching, an average of 9.05 days is found. The maximum is 13 days; minimum, 5 days. These records may be found in Table IV.

TABLE IV.—*Length of incubation period of eggs of the first brood of the codling moth, Roswell, N. Mex., 1912.*

Observation No.	Date of egg deposition.	Date of—			Duration of—		
		Red ring.	Black spot.	Hatching.	Red ring.	Black spot.	Incubation.
					Days.	*Days.*	*Days.*
1	Apr. 26	Apr. 29	May 4	May 6	5	2	10
2	26	29	4	7	5	3	11
3	26	29	4	8	5	4	12
4	26	29	4	9	5	5	13
5	28	May 3	5	7	2	2	9
6	28	3	5	8	2	3	10
7	28	3	5	9	2	4	11
8	29	3	5	7	2	2	8
9	29	3	5	8	2	3	9
10	29	3	5	9	2	4	10
11	May 2	6	9	10	3	1	8
12	2	6	9	12	3	2	10
13	3	7	10	12	3	2	9
14	3	7	10	13	3	3	10
15	3	7	10	14	3	4	11
16	4	10	12	14	2	2	10
17	4	10	12	15	2	3	11
18	4	10	12	16	2	4	12
19	4	10	12	17	2	5	13
20	5	12	14	16	2	2	11
21	5	12	14	17	2	3	12
22	6	12	15	17	3	2	11
23	6	12	15	19	3	4	13
24	8	14	18	19	4	1	11
25	8	14	18	20	4	2	12
26	9	15	18	20	3	2	11
27	9	15	18	21	3	3	12
28	10	16	19	21	3	2	11
29	10	16	19	22	3	3	12
30	11	18	20	21	2	1	10
31	12	18	20	21	2	1	9
32	12	18	20	22	2	2	10
33	13	19	21	23	2	2	10
34	13	19	21	24	2	3	11
35	15	18	20	22	2	2	7
36	15	18	20	22	2	2	7
37	16	19	21	22	2	1	6
38	16	19	21	23	2	2	7
39	17	20	22	23	2	1	6
40	17	20	22	24	2	2	7
41	18	21	23	24	2	1	6
42	18	21	23	25	2	2	7
43	19	23	24	25	1	1	6
44	20	22	24	25	2	1	5
45	20	22	24	26	2	2	6
46	21	23	25	26	2	1	5
47	21	23	25	27	2	2	6
48	22	24	27	28	3	1	6
49	22	24	27	29	3	2	7
50	23	25	27	29	2	2	6
51	23	25	27	30	2	3	7
52	23	25	27	31	2	4	8
53	27	30	31	June 2	1	2	6
54	27	30	31	3	1	3	7
55	30	June 2	June 4	6	2	2	7
Average					2.47	2.36	9.05
Maximum					5	5	13
Minimum					1	1	5

Time of hatching.—By reference to Table V it will be noted that the earliest first-brood eggs hatched May 7, and hatching continued more or less irregularly until June 2, when the last observation was made. Hence, eggs of the first brood were hatching for a period of 26 days, and were hatching in largest numbers from May 21 to May 26, reaching the maximum number on May 21.

THE FIRST BROOD OF LARVÆ.

Length of feeding period of larvæ.—The length of feeding period of larvæ of the first brood was determined from observations with 51 individuals as given in Table V. The average length of feeding was 21.52 days; maximum, 27 days; minimum, 15 days. In this instance the wintering larvæ were not isolated from transforming larvæ of the same brood.

TABLE V.—*Length of feeding period of larvæ of the first brood of the codling moth, Roswell, N. Mex., 1912.*

Date of hatching.	Number of individuals.	Length of feeding in specified days, being the time from hatching of egg to the leaving of fruit by larvæ.													Average days.	Minimum days.	Maximum days.	Total days.
		15	16	17	18	19	20	21	22	23	24	25	26	27				
May 7	2													2	.27	27	27	54
8	1										1				.24	24	24	24
12	3								1	1			1		23.6	22	26	71
17	4							2			1			1	23.25	21	27	93
20	4			1							2	1			22.5	17	25	90
21	18	1	1	2		4	1	3	1	2		1	1	1	20.6	15	27	370
22	2							1		1					22	21	23	44
23	5					1		2				2			22.2	19	25	111
26	9		1		2	1	2	1	2						19.3	16	22	174
30	1									1					23	23	23	23
June 1	1						1								20	20	20	20
2	1										1				24	24	24	24
	51	1	2	3	2	6	4	9	4	5	5	4	2	4	21.52	.....	.....	1,098

Larval life in the cocoon.—The larval life in the cocoon is generally considered to be the time required for making the cocoons, and is calculated from the time a transforming larva leaves the fruit until the time of pupation. The results of 41 observations show the average time consumed in constructing the cocoon as 5.24 days. The maximum time was 12 days; minimum, 2 days. These records may be found in Table VI.

TABLE VI.—*The making of cocoons by codling-moth larvæ of the first brood, Roswell, N. Mex., 1912.*

Date of leaving fruit.	Number of individuals.	Length of cocooning period in specified days, being the time from the leaving of fruit to the time of pupation.									Average days.	Minimum days.	Maximum days.	Total days.
		2	3	4	5	6	7	10	11	12				
June 2	2					1				1	9	6	12	18
3	3		1			1		1			6.3	3	10	19
4	2				1			1			7.5	5	10	15
5	1								1		11	11	11	11
6	1					1					6	6	6	6
7	1					1					6	6	6	9
8	6			5	1						4.13	4	5	25
9	5			1	2		1		1		6.4	4	11	32
10	1					1					6	6	6	6
11	1		1								3	3	3	3
12	2			2							4	4	4	8
13	4		2	1	1						3.75	3	5	15
14	4	2		1		1					3.5	2	6	14
15	3		1		1		1				5	3	7	15
16	3			2	1						4.3	4	5	13
19	2			1	1						4.5	4	5	9
	41	2	5	13	8	6	2	2	2	1	5.24	2	12	215

THE FIRST BROOD OF PUPÆ.

Time of pupation.—The earliest pupation of the first brood recorded occurred June 1 and the latest July 11. (See Table VII.)

Length of pupal stage.—From a total of 160 individual insects under observation in this connection the results show that the pupal period varied from 9 to 19 days, with an average of 12.11 days. These figures are given in Table VII.

TABLE VII.—*Pupal stage of the first brood of the codling moth, Roswell, N. Mex., 1912.*

Date of pupation.	Number of individuals.	Length of pupal period in specified days, being the time from date of pupation to the emergence of moth.									Average days.	Minimum days.	Maximum days.	Total days.
		9	10	11	12	13	14	15	16	19				
June 1	1					1					13	13	13	13
2	2				2						12	12	12	24
3	1					1					13	13	13	13
4	1				1						12	12	12	12
6	1						1				14	14	14	14
9	5					1	3		1		14.2	13	16	71
10	3						2		1		14.6	14	16	44
11	6			1	1	2		1		1	13.8	11	19	83
12	17			1	11	4	1				12.3	11	14	209
13	5				3	2					12.4	12	13	62
14	18			2	6	6	4				12.6	11	14	228
15	27				9	16	2				12.7	12	14	344
16	12				2	6	1	3			13.4	12	15	161
17	5				2	3					12.6	12	13	63
18	1					1					13	13	13	13
19	2			1	1						11.5	11	12	23
22	11		1	7	3						11.2	10	12	123
23	8		4	3	1						10.6	10	12	85
24	3		2	1							10.3	10	11	31
25	5		4	1							10.2	10	11	51
26	5		2	3							10.6	10	11	53
28	5		4		1						10.4	10	12	52
29	4		3	1							10.2	10	11	41
July 1	5		3	2							10.4	10	11	52
2	2		2								10	10	10	20
5	1	1									9	9	9	9
8	1	1									9	9	9	9
9	1			1							11	11	11	11
10	1				1						12	12	12	12
11	1					1	♂				13	13	13	13
	160	2	25	24	44	44	14	4	2	1	12.11	9	19	1,939

FIRST BROOD OF MOTHS.

Time of emergence.—The records of emergence of first-brood moths given in Table VIII cover observations with 786 individuals. The material used in this instance was secured from banded trees in orchards.

The first moth appeared June 9, while a maximum emergence occurred June 23, with irregularly decreasing numbers thereafter until July 22, when the last observation was made. The total emergence of 786 moths covered a period of 43 days.

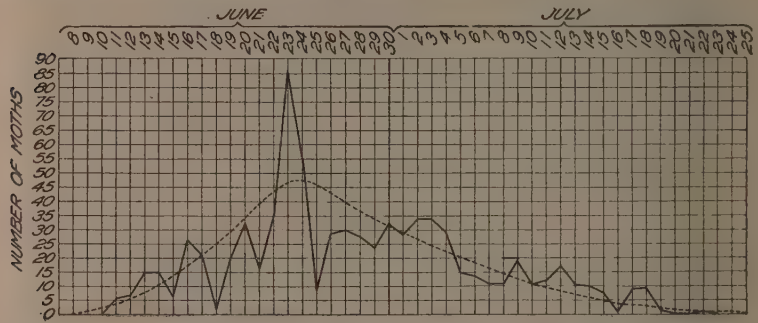

FIG. 2.—Emergence curve of codling moths of the first brood, Roswell, N. Mex., 1912. (Original.)

A graphic description of the emergence of moths of the first brood appears in figure 2.

TABLE VIII.—*Time of emergence of codling moths of the first brood from larvæ collected systematically from banded trees and kept in cages, Roswell, N. Mex., 1912.*

Date of emergence.	Number of moths.	Date of emergence.	Number of moths.
June 9	1	July 1	28
11	6	2	34
12	7	3	33
13	15	4	29
14	15	5	15
15	7	6	14
16	26	7	11
17	21	8	11
18	2	9	19
19	20	10	11
20	32	11	12
21	16	12	17
22	35	13	11
23	86	14	10
24	55	15	8
25	9	16	1
26	29	17	9
27	30	18	9
28	28	19	1
29	24	22	1
30	32		

Total emergence, 786 moths.

Time of oviposition.—By reference to Table IX it will be found that the earliest deposition by moths of the first brood was made June 14, while the last oviposition occurred July 23. Hence the period of oviposition was approximately 40 days.

TABLE IX.—*Egg deposition by codling moths of first brood in stock jars at Roswell, N. Mex., 1912.*

Cage No.	Number of moths per cage.	Date of—			Days—		
		Emergence of moth.	First oviposition.	Last oviposition.	Before oviposition.	Of oviposition.	From time of emergence to last oviposition.
1	12	June 11	June 14	June 17	3	3	6
2	15	13	17	27	4	10	14
3	14	14	16	24	2	8	10
4	9	15	18	23	3	5	8
5	23	16	19	22	3	3	6
6	20	17	21	26	4	5	9
7	16	19	23	24	4	1	5
8	23	20	23	27	3	4	7
9	19	21	23	28	2	5	7
10	27	22	25	29	3	4	7
11	39	23	25	29	2	4	6
12	40	24	27	29	3	2	5
13	37	25	27	July 2	2	5	7
14	21	26	28	2	2	4	6
15	52	27	28	3	1	5	6
16	35	28	30	6	2	6	8
17	30	29	July 1	5	2	4	6
18	22	30	2	6	2	4	6
19	25	July 1	2	8	1	6	7
20	36	2	4	7	2	3	5
21	35	3	5	8	2	3	5
22	42	4	6	9	2	3	5
23	40	5	8	13	3	5	8
24	26	6	8	14	2	6	8
25	20	7	9	12	2	3	5
26	26	8	11	16	3	5	8
27	31	9	12	16	3	4	7
28	22	10	13	19	3	6	9
29	14	11	13	21	2	8	10
30	33	12	15	18	3	3	6
31	9	13	17	21	4	4	8
32	10	14	20	22	6	2	8
33	14	15	19	23	4	4	8
Average					2.7	4.45	7.15
Maximum					6	11	14
Minimum					1	2	5

The results given in Table IX show that on an average the first eggs were laid 2.7 days after the time of emergence of moths and that oviposition extended on an average to 4.45 days. The average length of time from the date of moth emergence to the last date of oviposition was 7.15 days; maximum, 14 days; minimum, 5 days.

Length of life of moths.—A summary of observations on the length of life of 367 male moths and 411 female moths is recorded in Table X. A study of this table will show that the longevity of the males was shorter than that for the females. On an average the males lived 4.44 days and females 6.24 days. The maximum length of life for the males was 16 days, and for the females 15 days.

TABLE X.—*Length of life of male and female codling moths of the first brood, Roswell, N. Mex., 1912.*

Summary of records of 778 individual moths.				Summary of records of 778 individual moths.			
Male.		Female.		Male.		Female.	
Length of life.	Number of moths.	Length of life.	Number of moths.	Length of life.	Number of moths.	Length of life.	Number of moths.
Days.		*Days.*		*Days.*		*Days.*	
1	2	1	0	10	1	10	18
2	25	2	10	11	1	11	7
3	72	3	25	12	0	12	2
4	99	4	44	13	0	13	1
5	98	5	82	14	0	14	1
6	48	6	87	15	0	15	2
7	10	7	57	16	1	16	0
8	8	8	48				
9	2	9	27		367		411

Average length of life of male moths, 4.44 days.
Average length of life of female moths, 6.24 days.
Maximum length of life of male moths, 16 days.
Maximum length of life of female moths, 15 days.
Minimum length of life of male moths, 1 day.
Minimum length of life of female moths, 2 days.

LENGTH OF LIFE CYCLE OF THE FIRST GENERATION.

Records of the observations on the life cycle of the first generation show that only 7 individuals completed the stages comprising the total life cycle of the insect. From this number an average of 51.14 days is found to represent the length of the period from date of deposition of eggs to emergence of moths of the same generation. The maximum period is 61 days; the minimum, 40 days. (See Table XI.)

TABLE XI.—*Length of life cycle of first generation of codling moth, Roswell, N. Mex., 1912.*

Date of egg deposition.	Number of individuals.	Moths emerged in specified days from time of deposition of eggs of the same generation.							Average days.	Minimum days.	Maximum days.	Total days.
		40	45	46	52	56	58	61				
April 26	1						1		58	58	58	58
May 10	1							1	61	61	61	61
11	2				1	1			54	52	56	108
20	2	1	1						42.5	40	45	85
27	1			1					46	46	46	46
	7	1	1	1	1	1	1	1	51.14			358

A summary of results from observations on the separate stages of the first generation of the codling moth shows the total life cycle of the insect when computed by individual stages to compare very closely with the corresponding figures in Table XI. The length of life cycle by addition of separate stages is found to be 50.62 days as shown in Table XII, a difference of only 0.54 day.

TABLE XII.—*Summary of results from experiments on the separate stages of the first generation of the codling moth, Roswell, N. Mex., 1912.*

Complete life cycle of first generation.	Number of days.		
	Average.	Maximum.	Minimum.
Incubation of eggs	9.05	13	5
Feeding period of larvæ	21.52	27	15
Making of cocoons	5.24	12	2
Pupal stages	12.11	19	9
Time before egg deposition	2.7	6	1
Total	50.62	77	32

THE SECOND GENERATION.

THE SECOND BROOD OF EGGS.

Length of incubation.—Observations to determine the length of the period of incubation of eggs of the second brood were begun June 14 and continued until late in July. Eggs were deposited in large numbers during that period, and very accurate data regarding the length of the separate stages observed could be obtained. The average length of time from date of deposition to appearance of red ring was found to be 4.92 days; maximum, 4 days; minimum, 2 days. The average length of time from oviposition to appearance of the black spot was 4.26 days; maximum, 6 days; minimum, 3 days. For the period of time covering the duration of incubation an average of 5.62 days is determined; maximum, 8 days; minimum, 4 days. These records are found in Table XIII.

TABLE XIII.—*Length of incubation of second brood of eggs of the codling moth at Roswell, N. Mex., 1912.*

Observation No.	Number of eggs.	Date of—				Days for—		
		Oviposition.	Appearance of red ring.	Appearance of black spot.	Hatching.	Red ring.	Black spot.	Incubation.
1	8	June 14	June 16	June 20	June 21	2	6	7
2	68	16	20	22	23	4	6	7
3	17	16	20	22	24	4	6	8
4	56	17	20	22	23	3	5	6
5	40	17	20	23	24	3	6	7
6	15	18	20	23	24	2	5	6
7	7	18	20	23	25	2	5	7
8	5	19	22	24	25	3	5	6
9	2	19	22	24	26	3	5	7
10	3	20	23	24	25	3	4	5
11	18	21	24	25	27	3	4	6
12	70	22	25	27	28	3	5	6
13	52	23	26	27	28	3	4	5
14	27	23	26	28	29	3	5	6
15	42	24	27	28	29	2	3	5
16	31	24	27	28	30	3	4	6
17	24	25	28	29	30	3	4	5
18	24	25	28	29	July 1	3	4	6
19	29	26	28	30	1	2	4	5
20	12	26	28	30	2	2	4	6
21	80	27	29	July 1	2	2	4	5
22	43	27	29	1	3	2	4	6
23	100	28	July 1	2	3	3	4	5

TABLE XIII.—*Length of incubation of second brood of eggs of the codling moth at Roswell, N. Mex., 1912*—Continued.

Observation No.	Number of eggs.	Date of—				Days for—		
		Oviposition.	Appearance of red ring.	Appearance of black spot.	Hatching.	Red ring.	Black spot.	Incubation.
24	94	June 28	July 1	July 2	July 4	3	4	6
25	42	29	2	3	4	3	4	5
26	27	29	2	3	5	3	4	6
27	87	30	3	4	5	3	4	5
28	37	July 1	3	5	6	2	4	5
29	22	1	4	6	7	3	5	6
30	29	2	5	6	7	3	4	5
31	18	2	5	6	8	3	4	6
32	216	3	6	7	8	3	4	5
33	7	3	6	7	9	3	4	6
34	109	4	7	8	9	3	4	5
35	82	4	7	8	10	3	4	6
36	304	5	8	9	10	3	4	5
37	48	5	8	9	11	3	4	6
38	187	6	8	10	11	2	4	5
39	25	6	8	10	12	2	4	6
40	16	7	10	11	12	3	4	5
41	2	7	10	11	13	3	4	6
42	163	8	11	12	13	3	4	5
43	21	8	11	12	14	3	4	6
44	297	9	12	13	14	3	4	5
45	15	9	12	13	15	3	4	6
46	102	10	13	14	15	3	4	5
47	77	10	13	14	16	3	4	6
48	43	11	13	14	15	2	3	4
49	153	11	14	15	16	3	4	5
50	50	12	14	16	17	2	4	5
51	14	12	15	17	18	3	5	6
52	14	13	15	16	17	2	3	4
53	30	13	16	17	18	3	4	5
54	67	14	16	18	19	2	4	5
55	11	14	17	18	20	3	4	6
56	110	15	18	19	20	3	4	5
57	22	15	18	19	21	3	4	6
58	29	16	18	20	21	2	4	5
59	12	16	19	20	22	3	4	6
60	82	17	20	21	22	3	4	5
61	26	17	20	22	23	3	5	6
62	22	18	21	22	23	3	4	5
63	6	18	21	23	24	3	5	6
64	114	19	22	23	24	3	4	5
65	134	20	23	24	25	3	4	5
66	8	20	23	25	26	3	5	6
67	61	21	24	25	26	3	4	5
68	21	21	24	25	27	3	4	6
69	5	22	26	27	28	4	5	6
Average						4.92	4.26	5.62
Maximum						4	6	8
Minimum						2	3	4

Time of hatching.—The data in Table XIII, show that the first observation of hatching of eggs of the second brood occurred June 21, and continued quite regularly until July 28, thus covering a period of approximately five weeks.

THE SECOND BROOD OF LARVÆ.

Length of feeding period.—Records on the length of feeding period of 489 individual insects are brought together in Table XIV. This period covered a range of from 14 to 44 days, both transforming and wintering larvæ being included. The average length of feeding was found to be 21.23 days; maximum, 44 days; minimum, 14 days.

TABLE XIV.—*Length of feeding period of codling-moth larvæ of the second brood, Roswell, N. Mex., 1912.*

Date of hatching.	Number of individuals.	Length of feeding period in specified days, being the time from hatching of egg to leaving of fruit by larvæ.																									Average days.	Minimum days.	Maximum days.	Total days.
		14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	44				
June 23	25	....	1	3	3	8	1	4	2	....	2	....	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	18.8	15	25	470
24	18	....	1	3	5	2	3	4	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	17.83	15	20	321
25	8	....	....	2	1	1	....	1	....	2	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	19.25	16	23	154
26	2	....	....	1	....	....	....	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	18	16	20	36
28	17	....	4	2	2	1	4	2	....	....	1	....	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	19.29	15	25	328
29	13	3	....	2	....	3	2	1	1	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	17.61	14	22	229
30	10	....	1	3	1	1	1	1	1	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	18	15	22	180
July 1	12	....	....	1	2	5	1	2	....	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	18.41	16	22	221
2	9	....	....	....	2	1	1	....	1	2	1	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	20.33	17	24	183
3	40	....	2	2	....	4	1	1	3	3	7	7	2	....	....	2	1	....	....	3	....	....	....	....	1	1	....	23.42	15	38	937
4	23	1	....	2	2	....	4	1	....	....	3	1	1	....	....	1	2	....	....	....	....	2	2	1	....	....	....	24.08	14	36	554
5	16	....	....	2	....	1	1	....	1	....	....	....	3	2	2	1	1	1	....	....	....	....	....	....	....	....	1	25.12	16	44	402
6	14	1	1	....	....	....	2	....	3	1	2	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	20.57	14	24	288
7	25	2	....	....	2	6	5	4	4	....	3	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	19.75	17	24	494
8	18	....	1	....	....	5	4	1	3	....	....	2	....	....	....	....	....	....	1	....	....	....	....	....	....	....	....	20.55	15	31	370
9	25	....	....	....	7	2	3	2	....	2	1	1	....	....	....	....	2	1	1	1	1	....	....	....	1	....	....	22.56	17	37	564
10	24	....	1	3	3	2	3	1	2	3	1	1	2	....	....	....	....	....	....	....	1	....	....	1	....	....	....	20.87	15	36	501
11	28	....	1	1	2	....	3	1	1	....	....	....	12	1	1	1	....	....	....	1	1	1	1	....	....	....	....	24.21	15	35	678
12	24	....	1	....	....	4	1	5	....	....	....	....	....	2	....	3	2	....	....	....	....	....	....	....	....	....	....	22.45	15	29	539
13	26	....	....	....	3	3	1	3	4	3	2	1	1	4	1	....	....	....	....	....	....	....	....	....	....	....	....	21.53	17	27	560
14	24	....	....	....	....	2	4	2	9	1	1	....	....	....	....	1	....	1	3	....	....	....	....	....	....	....	....	22.37	18	31	537
15	7	....	....	....	2	....	....	1	....	1	....	....	....	....	1	....	....	....	....	....	....	....	....	....	1	1	....	25.14	17	37	176
16	21	....	....	1	....	1	8	1	2	2	2	....	....	....	2	2	....	....	....	....	....	....	....	....	....	....	....	21.33	16	28	448
17	14	....	....	....	2	4	....	2	....	....	....	2	3	....	....	....	....	....	1	....	....	....	....	....	....	....	....	21.42	17	31	300
18	7	2	....	1	2	....	....	....	1	....	....	....	....	....	....	1	....	....	....	....	....	....	....	....	....	....	....	18.14	14	28	127
19	10	....	....	3	....	1	....	....	3	....	1	1	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	20.10	16	25	201
20	19	....	4	....	2	2	2	5	....	3	....	....	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	18.89	15	25	359
21	10	....	....	2	....	2	....	....	....	....	....	....	4	....	....	1	1	....	....	....	....	....	....	....	....	....	....	22.50	16	29	225
	489	9	18	34	43	61	55	46	41	29	33	20	32	9	7	13	9	3	6	5	3	3	3	3	3	1	1	21.23	.....	.....	10,382

Length of feeding period of wintering larvæ.—The records on the length of feeding period of wintering larvæ of the second brood were separated from those of the transforming larvæ of the same generation, and by reference to Table XV results of observations with 211 individuals may be found. An average of 22.77 days is recorded for the entire number under observation as contrasted with an average of 21.23 days for both transforming and wintering larvæ of this generation.

The maximum period is 44 days; minimum, 15 days.

TABLE XV.—*Length of feeding of wintering second-brood larvæ of the codling moth, Roswell, N. Mex., 1912.*

Days of hatching.	Number of individuals.	Length of feeding period in specified days.																								Average days.	Maximum days.	Minimum days.	Total days.
		15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	44				
June 28	3		2	1																							16.3	17	16	49
30	1				1																						18.0	18	18	18
July 1	3						2		1																		21.0	22	20	42
2	2									1	1																23.5	24	23	47
3	16								2	1	4	1	1			1			4					1	1		27.9	38	22	446
4	7											1				1					2	2	1				32.6	36	25	228
5	10				1	1			1	1	1	2				1	1									1	25.9	44	18	259
6	14	1				2		2	5	3	1																21.3	24	15	298
7	11			2	3	1	1	1		2	1																19.8	24	17	218
8	9	1		1	2	2	1				1				1												19.8	28	15	178
9	6					1	1									1	1			1				1			28.0	37	19	168
10	12	1	2	1	1	2	1		1	1		1							1								20.2	32	15	242
11	13			1		1		1			4		1	1				1	1	1	1						25.8	34	17	336
12	18	1			3	1	6			3					2	2											21.7	29	15	391
13	12		1			1		2	3				4	1													22.8	27	16	274
14	17			1	1	3	1	6		1							1	3									22.6	31	17	384
15	3													1									1	1			33.3	37	27	100
16	14					6		2	1	1				2	2												22.2	28	19	311
17	7				2		1				1	2						1									23.0	31	18	161
18	2							1							1												24.5	28	21	49
19	9		1	1	1			2	1	1	1	1															20.8	25	16	187
20	13	1			4	1	3		3			1															19.7	25	15	257
21	9		1		2							4				1	1										23.2	29	16	209
Total	211	5	7	8	21	22	17	17	18	15	15	13	6	5	7	7	3	5	6	2	3	2	2	3	1	1	[1] 22.77			4,806

[1] Average.

Larval life in the cocoon.—The length of the period of time which the larvæ require to construct a cocoon preparatory to pupation or wintering, is found to vary considerably when large numbers of the larvæ are kept under observation. In Table XVI will be found the results of observations on 282 individual insects. Of this number 70 larvæ required 5 days, and an average period of 5.16 days is found to exist. The maximum time was 17 days; minimum, 1 day.

TABLE XVI.—*The making of cocoons of the second generation of the codling moth, Roswell, N. Mex., 1912.*

Date of leaving fruit.	Number of individuals.	Length of cocooning period in specified days.															Average days.	Minimum days.	Maximum days.	Total days.
		1	2	3	4	5	6	7	8	9	10	11	12	13	16	17				
July 8	1			1													3.0	3	3	3
9	4			1	2			1									4.5	3	7	18
10	6				4	2											4.3	4	5	26
11	12		2	3	2	1	4										4.2	2	6	50
12	5			1	3	1											4.0	3	5	20
13	12			1	8	1	1								1		5.2	3	16	62
14	7				2	1	3	1									5.4	4	7	38
15	5	1			1	1	1						1				5.6	1	12	28
16	5				2	2	1										4.8	4	6	24
17	11			1	2	2	3	2								1	6.4	3	17	70
18	12			1	1	3	3	2									6.0	3	9	72
19	12				3	5	2	2									5.3	4	7	63
20	6				1	5											4.8	4	5	29
21	13				4	3	4	1						1			5.8	4	13	75
22	2					2											5.0	5	5	10
23	8		2		5		1										3.7	2	6	30
24	7		1	1		2			3								5.6	2	8	39
25	24		1	1	1					1							4.8	2	10	19
26	21	2	2	3	4	2	7		1								4.3	1	8	91
27	21			4	1	8	3	3	1		1						5.4	3	10	113
28	8			1		3	2	1				1					6.0	3	11	48
29	6				1	1	3		1								5.8	4	8	35
30	8				2	3		2					1				6.1	4	12	49
31	7						1	5					1				7.6	6	12	53
Aug. 1	11		1	2	1	3	3	1									4.8	2	7	52
2	7		1		1	4		1									4.7	2	7	33
3	7			1	3	1	1	1									4.7	3	7	33
4	28		1	2	3	11	7	2	2								5.3	2	8	147
5	4				2	1	1										4.8	4	6	19
6	7		1		4	1			1								4.4	2	8	31
7	5		2	1	2												3.0	2	4	15
8	3						1		1	1							8.3	6	9	25
9	3				1		1	1									5.7	4	7	17
10	2				2												4.0	4	4	8
11	1							1									7.0	7	7	7
15	1					1											5.0	5	5	5
Total	282	3	14	25	68	70	53	27	10	3	2	1	3	1	1	1	5.16	.....	.....	1,457

THE SECOND BROOD OF PUPÆ.

Time of pupation.—Investigations show the earliest recorded pupation of individuals of this brood to have occurred July 14, and the latest on August 31. Actual pupations are thus shown to cover a period of 48 days. (See Table XVII.)

Length of pupal stage.—A record on the length of the pupal stage was established from observations with 211 individuals, and reveals the fact that the pupal period varied from 8 to 19 days. The average period was 11.23 days. These records are found in Table XVII.

TABLE XVII.—*Pupal stage of second brood codling moth, Roswell, N. Mex., 1912.*

Date of pupation.	Number of individuals.	Length of pupal period in days.												Average days.	Minimum days.	Maximum days.	Total days.
		8	9	10	11	12	13	14	15	16	17	18	19				
July 14	15			12	2	1								10.4	10	12	156
15	4		1		3									10.5	9	11	42
16	5			5										10	10	10	50
17	5		1	2	2									10.2	9	11	51
18	7				7									11	11	11	77
19	15		1	5	8					1				10.86	9	16	163
20	15			10	5									10.33	10	11	155
21	14			3	5	5	1							11.28	10	13	158
22	16		2	5	7	2								10.56	9	12	169
23	13			3	6	4								11.07	10	12	144
24	2					1	1							12.5	12	13	25
25	1				1									11	11	11	11
26	9			1	3	5								11.44	10	12	103
27	10			2	7		1							11	10	13	110
28	11			5	4	2								10.72	10	12	118
29	5			2				2					1	13.4	10	19	67
30	3	1	1				1							10	8	13	30
31	2				2									11	11	11	22
Aug. 1	14	1		6		6	1							10.92	8	13	153
2	3				2	1								11.33	11	12	34
3	8			5	1			2						11.12	10	14	89
4	3			1	2									10.66	10	11	32
5	1		1											9	9	9	9
9	11				10	1								11.09	11	12	122
10	2				2									11	11	11	22
13	2			1		1								11	10	12	22
14	2				2									11	11	11	22
16	3				2		1							11.66	11	13	35
17	1					1								12	12	12	12
19	2				1	1								11.5	11	12	23
20	1				1									11	11	11	11
25	2						1			1				14.5	13	16	29
26	1											1		18	18	18	18
27	2		1		1									10	9	11	20
31	1			1										10	10	10	10
Total	211	2	8	69	86	31	7	4		2		1	1	11.23			2,314

THE SECOND BROOD OF MOTHS.

Time of emergence.—The records on time of emergence of codling moths of the second generation may be found in Table XVIII. The earliest emergence of this brood occurred July 18, when nine moths emerged. Emergence continued more or less regularly until a maximum number of 242 was reached on August 7. The last emergence of which record was made occurred September 11.

TABLE XVIII.—*Time of emergence of codling moths of the second generation, Roswell, N. Mex., 1912.*

Date of emergence.	Number of moths.	Date of emergence.	Number of moths.
July 18	9	Aug. 16	114
19	11	17	70
20	23	18	55
21	10	19	66
22	44	20	36
23	58	21	33
24	68	22	40
25	100	23	44
26	93	24	29
27	47	25	22
28	91	26	17
29	145	27	32
30	121	28	16
31	72	29	16
Aug. 1	178	30	10
2	125	31	6
3	99	Sept. 1	6
4	199	2	9
5	181	4	7
6	216	5	4
7	242	6	1
8	179	7	2
9	109	8	1
10	194	10	1
11	152	11	1
12	167		
13	166		
14	55		
15	56	Total	3,848

Moths from band record larvæ.—In all, 5,320 larvæ of the second brood were collected systematically from banded trees in orchards and kept in cages in order that records might be obtained on emergence of moths from such sources. From the total larvæ secured in this way there emerged 3,848 moths, thus showing that 72.34 per cent of the larvæ under observation proved to be transforming larvæ. These records are shown in Table XIX.

TABLE XIX.—*Number of codling moths emerging from second-brood larvæ collected systematically from banded trees and kept in cages. Roswell, N. Mex., 1912.*

Date of collection.	Number of larvæ.	Number of moths.	Date of collection.	Number of larvæ.	Number of moths.
July 7	66	57	Aug. 6	235	159
10	179	162	9	261	131
13	303	249	12	232	73
16	451	372	15	142	28
19	410	368	18	110	20
22	609	530	21	88	12
25	678	596	24	86	2
28	623	483	27	88	1
31	399	354			
Aug. 3	360	251	Total	5,320	3,848

The rate and duration of the emergence of codling moths of this brood is described graphically in figure 3. As shown in Table XVIII, a maximum number emerged August 7, various fluctuations having occurred preceding that date and continuing throughout the period,

The time of oviposition in orchards may be determined with fair precision from the combined data on the habits of the moths in captivity and from the results of the rearing experiments.

In conducting the experiments, the results of which are shown in Table XX, eggs of the codling moth were readily obtained by confining a number of moths together in cages. It is not possible by this method to determine the number of eggs thus produced, but the time and period of egg deposition can be ascertained.

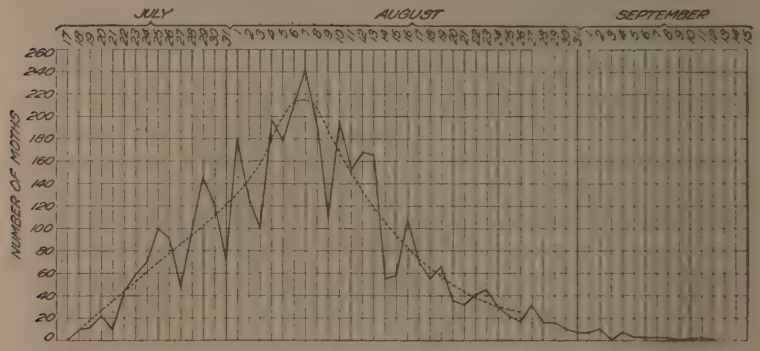

FIG. 3.—Emergence curve of codling moths of the second brood, Roswell, N. Mex., 1912. (Original.)

The results show the average length of time from emergence of moths until first oviposition to be 2.2 days; maximum, 4 days; minimum, 2 days. The average length of the period for the duration of oviposition was 7.1 days; maximum, 12 days; minimum, 1 day. From time of emergence to last oviposition the average was 9.3 days; maximum, 14 days; minimum, 6 days.

TABLE XX.—*Egg deposition by codling moths of the second brood, Roswell, N. Mex., 1912.*

Cage. No.	Number of moths per cage.	Date of—			Days—		
		Emergence of moths.	First oviposition.	Last oviposition.	Before oviposition.	Of oviposition.	From time of emergence to last oviposition.
1	26	July 18	July 21	July 28	3	7	10
2	14	19	23	24	4	1	5
3	28	20	24	26	4	2	6
4	26	21	24	29	3	5	8
5	37	22	24	29	2	5	7
6	35	23	26	Aug. 3	3	10	13
7	36	24	26	4	2	9	11
8	32	25	27	8	2	12	14
9	40	26	28	2	2	5	7
10	40	27	29	10	2	12	14
11	43	28	30	6	2	7	9
12	40	29	31	7	2	7	9
13	47	30	Aug. 1	8	2	7	9
14	40	31	2	12	2	10	12
15	43	Aug. 1	3	9	2	6	8
16	45	2	4	10	2	6	8
17	47	3	5	14	2	9	11
18	52	4	6	14	2	8	10
19	33	5	7	11	2	4	6
20	43	6	9	19	3	10	13
21	40	7	9	14	2	5	7
22	50	8	10	19	2	9	11
23	40	9	11	23	2	12	14
24	33	10	13	22	3	9	12
25	34	11	13	24	2	11	13
26	38	12	14	23	2	9	11
27	25	13	15	23	2	8	10
28	30	14	17	22	3	5	8
29	30	15	17	24	2	7	9
30	35	16	18	29	2	11	13
31	35	17	19	25	2	6	8
32	40	18	20	27	2	7	9
33	37	19	21	27	2	6	8
34	30	20	22	28	2	6	8
35	33	21	23	28	2	5	7
36	27	22	24	30	2	6	8
37	43	23	25	Sept. 5	2	11	13
38	27	24	26	4	2	9	11
39	20	25	27	3	2	7	9
40	17	26	28	3	2	6	8
41	32	27	29	4	2	6	8
42	17	28	30	4	2	5	7
43	24	29	31	5	2	5	7
44	10	31	Sept. 3	6	3	3	6
45	16	Sept. 2	5	8	3	3	6
Average days					2.2	7.1	9.3
Maximum days					4	12	14
Minimum days					2	1	6

Length of life of moths.—Observations in this connection were made with a total of 1,416 moths confined in cages in order to secure mortality records. The results obtained with this number of individual moths give the average length of life of male moths to be 5.49 days; female moths, 7.58 days; maximum length of life of male moths, 12 days; female moths, 24 days; the minimum length of life of moths of both sexes is identical, 2 days. These records may be found in Table XXI.

TABLE XXI.—*Length of life of male and female codling moths of the second brood. Summary of records of 1,416 individual moths, Roswell, N. Mex., 1912.*

Male.		Female.	
Length of life.	Number of moths.	Length of life.	Number of moths.
Days.		*Days.*	
2	3	2	4
3	54	3	11
4	132	4	38
5	165	5	69
6	151	6	147
7	90	7	163
8	40	8	118
9	9	9	66
10	8	10	53
11	3	11	33
12	4	12	25
13	0	13	7
14	0	14	8
15	0	15	8
16	0	16	4
17	0	17	2
24	0	24	1

Average length of life of male moths, 5.49 days; average length of life of female moths, 7.58 days; maximum length of life of male moths, 12 days; maximum length of life of female moths, 24 days; minimum length of life of male moths, 2 days; minimum length of life of female moths, 2 days.

LIFE CYCLE OF SECOND GENERATION.

In order to secure accurate data on the length of the life cycle of the codling moth of the second generation, observations were conducted by means of which the length of time from the date of egg deposition to emergence of moth could be determined. A total of 283 individual moths were used in this test, and the results show a range of variation in the life cycle from 32 to 68 days, with an average period of 41.26 days. These results are shown in Table XXII.

TABLE XXII.—*Length of life cycle of the second generation of the codling moth, Roswell, N. Mex., 1912.*

Date of egg deposition.	Number of individuals.	Moths emerged in specified days from time of deposition of eggs of the same generation.																							Average days.	Minimum days.	Maximum days.	Total days.
		32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	68				
June 16	21				1	3	1		6	1	2	1	2			1	2		1							40.6	35	49	853
17	18					1	3	2	2	2	3	2	1	1	1											40.0	36	45	720
18	6					2		1						1	1	1										40.8	36	46	245
19	1						1																			37.0	37	37	37
22	14				1			1	3		1	2	2	1		1	1		1							41.9	35	49	587
24	13			3				1	1	3	3		1		1											39.2	34	45	510
25	10		1		2			2	1	1		2		1												38.6	33	44	386
26	11						4	2	1			3	1													39.3	37	43	432
27	33						1	3	1	1	5	5	4	4		5		2	1	1						41.9	37	50	1,382
29	18		1		2		1	3	4	1		1	1	1	1		1		1							40.0	33	49	720
30	7								1			1			1			1	1		2					46.4	39	51	325
July 1	20		1					1	2	2		5	5	3		1										41.6	33	46	832
3	26					1		1	6	2	3	4		2	2	1			1			2		1		42.6	36	54	1,110
4	7			1					1		1	2			1										1	44.4	34	68	311
6	13			2				1			1		7			1	1									41.6	34	47	541
7	20						1	1			1	7	2	5		1	2									42.8	37	47	856
8	10								1	1		3	1			1		1	1				1			44.4	39	53	444
9	4							1				1	2													41.5	38	43	166
10	7						1	1		1	2					2										41.3	37	46	289
12	7					1		3		1	1			1												39.3	36	44	275
13	5	1						1	1	1														1		40.6	32	54	203
14	3					1	1							1												39.0	36	44	117
15	8			2		2	1	1				1	1													37.5	34	43	300
16	1					1																				36.0	36	36	36
	283	1	3	8	6	12	15	26	31	17	23	40	30	21	8	15	7	4	7	1	2	2	1	2	1	41.26	.....	.....	11,677

Accumulated records on the time of development of the codling moth in its stages of egg, larva, and pupa are summarized in Table XXIII. A sum composed of the average figures given under each of the several stages shows a total life cycle of 41.38 days. This sum is found to correspond very closely with the length of life cycle as given in Table XXII, there being a difference of but 0.12 day.

TABLE XXIII.—*Summary records on the time of development of the codling moth of the second generation in its stages of egg, larva, and pupa, Roswell, N. Mex., 1912.*

Date of egg deposition.	Number of individuals.	Days of incubation.	Number of individuals.	Length of period of feeding larva.			Number of individuals.	Length of cocooning period.			Number of individuals.	Length of pupal stage.			Number of individuals.	Total length of life cycle.		
				Average days.	Minimum days.	Maximum days.		Average days.	Minimum days.	Maximum days.		Average days.	Minimum days.	Maximum days.		Average days.	Minimum days.	Maximum days.
June 16	21	147	21	18.8	15	25	21	4.04	3	7	21	10.7	8	19	21	40.6	35	49
17	18	126	18	17.8	15	20	18	4.8	4	7	18	10.3	8	13	18	40.0	36	45
18	6	42	6	19.3	16	23	6	3.6	2	5	6	10.8	10	12	6	40.8	36	46
19	1	7	1	16.0	16	16	1	5.0	5	5	1	9.0	9	9	1	37.0	37	37
22	14	84	14	18.5	15	25	14	5.3	2	17	14	10.5	7	14	14	41.9	35	49
24	13	65	13	16.1	14	22	13	5.7	1	16	13	10.9	5	17	13	39.2	34	45
25	10	50	10	18.1	15	22	10	4.4	3	6	10	11.1	9	16	10	38.6	33	44
26	11	55	11	18.1	16	22	11	5.1	4	7	11	11.1	9	15	11	39.3	37	43
27	33	190	33	20.7	15	25	33	5.2	1	10	33	11.4	7	22	33	41.9	37	50
29	18	90	18	19.7	14	29	18	4.4	2	7	18	10.8	8	13	18	40.0	33	49
30	7	35	7	24.0	16	28	7	7.7	5	13	7	9.7	5	13	7	46.4	39	51
July 1	20	117	20	19.5	14	23	20	5.3	3	10	20	11.1	9	14	20	41.6	33	46
3	26	147	26	21.0	17	32	26	5.8	2	12	26	10.3	8	15	26	42.6	36	54
4	7	42	7	21.1	16	36	7	5.14	2	11	7	12.1	10	21	7	44.4	34	68
6	13	65	13	21.3	15	25	13	4.3	2	6	13	11.0	8	16	13	41.6	34	47
7	20	114	20	21.5	17	28	20	5.9	3	7	20	10.3	3	13	20	42.8	37	47
8	10	60	10	21.3	18	28	10	5.5	3	8	10	11.3	10	13	10	44.4	39	53
9	4	24	4	19.0	17	22	4	5.5	4	7	4	11.0	9	12	4	41.5	38	43
10	7	42	7	19.6	16	23	7	4.9	2	6	7	10.8	10	14	7	41.3	37	46
12	7	35	7	19.0	17	24	7	4.3	2	8	7	11.1	10	13	7	39.3	36	44
13	5	25	5	15.6	14	17	5	4.6	3	7	5	14.8	10	26	5	40.6	32	54
14	3	14	3	17.7	16	21	3	6.7	5	9	3	10.0	10	10	3	39.0	36	44
15	8	40	8	16.5	15	20	8	5.8	4	8	8	10.1	9	11	8	37.5	34	43
16	1	5	1	16.0	16	16	1	4.0	4	4	1	11.0	11	11	1	36.0	36	36
	283	.....	283	19.6	.....	.....	283	5.19	.....	.....	283	10.87	.....	.....	283	41.26	.....	.....

Total days incubation for all eggs, 1,621; average number of days incubation, 5.72.

THE THIRD GENERATION.

THE THIRD BROOD OF EGGS.

Length of incubation.—In Table XXIV will be found the results of 96 observations of eggs of the codling moth in an endeavor to determine the length of the several stages from time of deposition until hatching occurs. The average length of time from date of deposition to the appearance of the red ring was 3.22 days; maximum, 5 days; minimum, 2 days. The average time until the appearance of the black spot was 4.22 days; maximum, 6 days; minimum, 3 days. From date of deposition until time of hatching the average period was 5.75 days; maximum, 9 days; minimum, 4 days.

TABLE XXIV.—*Length of incubation of third brood of eggs of the codling moth at Roswell, N. Mex., 1912.*

Observation No.	Number of eggs.	Date of—				Days for—		
		Oviposition.	Appearance of red ring.	Appearance of black spot.	Hatching.	Red ring.	Black spot.	Incubation.
1	53	July 22	July 24	July 25	July 26	2	3	4
2	46	22	24	25	27	2	3	5
3	112	23	26	27	28	3	4	5
4	30	23	26	27	29	3	4	6
5	120	24	27	28	29	3	4	5
6	26	24	27	28	30	3	4	6
7	506	25	28	29	30	3	4	5
8	42	25	28	29	31	3	4	6
9	401	26	29	30	31	3	4	5
10	103	26	29	30	Aug. 1	3	4	6
11	342	27	30	31	1	3	4	5
12	127	27	30	31	2	3	4	6
13	192	28	31	Aug. 1	2	3	4	5
14	46	28	31	1	3	3	4	6
15	203	29	Aug. 1	2	3	3	4	5
16	151	29	1	2	4	3	4	6
17	341	30	2	3	4	3	4	5
18	85	30	2	3	5	3	4	6
19	432	31	3	4	5	3	4	5
20	70	31	3	4	6	3	4	6
21	(1)	Aug. 1	4	5	6	3	4	5
22	(1)	1	4	5	7	3	4	6
23	195	2	5	6	7	3	4	5
24	15	2	5	6	8	3	4	6
25	160	3	6	7	8	3	4	5
26	15	3	6	7	9	3	4	6
27	227	4	7	8	9	3	4	5
28	5	4	7	8	10	3	4	6
29	158	5	8	9	10	3	4	5
30	12	5	8	9	11	3	4	6
31	100	6	9	10	11	3	4	5
32	8	6	9	10	12	3	4	6
33	100	7	10	11	12	3	4	5
34	2	7	10	11	13	3	4	6
35	307	8	11	12	13	3	4	5
36	102	8	11	12	14	3	4	6
37	195	9	12	13	14	3	4	5
38	12	9	12	13	15	3	4	6
39	300	10	13	14	15	3	4	5
40	16	10	13	14	16	3	4	6
41	90	11	14	15	16	3	4	5
42	110	11	14	15	17	3	4	6
43	104	12	15	16	17	3	4	5
44	6	12	15	16	18	3	4	6
45	80	13	16	17	18	3	4	5
46	180	13	16	17	19	3	4	6
47	200	14	17	18	19	3	4	5
48	109	14	17	18	20	3	4	6
49	207	15	18	19	20	3	4	5
50	77	15	18	19	21	3	4	6
51	60	16	19	20	21	3	4	5
52	80	16	19	20	22	3	4	5
53	116	17	20	21	22	3	4	6
54	6	17	20	21	23	3	4	6

TABLE XXIV.—*Length of incubation of third brood of eggs of the codling moth at Roswell, N. Mex., 1912*—Continued.

Observation No.	Number of eggs.	Date of—				Days for—		
		Oviposition.	Appearance of red ring.	Appearance of black spots.	Hatching.	Red ring.	Black spot.	Incubation.
55	329	Aug. 18	Aug. 21	Aug. 22	Aug. 23	3	4	5
56	123	18	21	22	24	3	4	6
57	137	19	22	23	24	3	4	5
58	5	19	22	23	25	3	4	6
59	120	20	23	24	25	3	4	5
60	112	20	23	24	26	3	4	6
61	92	21	24	25	26	3	4	5
62	225	21	24	25	27	3	4	6
63	125	22	25	26	27	3	4	5
64	31	22	25	26	28	3	4	6
65	142	23	26	27	28	3	4	5
66	54	23	26	27	29	3	4	6
67	97	24	27	28	29	3	4	5
68	7	24	27	28	30	3	4	6
69	302	25	28	29	30	3	4	5
70	107	25	28	29	31	3	4	6
71	75	26	29	30	31	3	4	5
72	341	26	29	30	Sept. 1	3	4	6
73	7	27	30	31	1	3	4	5
74	160	27	30	31	2	3	4	6
75	24	28	Sept. 1	Sept. 2	3	4	5	6
76	8	28	1	2	4	4	5	7
77	52	29	2	3	4	4	5	6
78	16	29	2	3	5	4	5	7
79	90	30	3	4	5	4	5	6
80	6	30	3	4	6	4	5	7
81	4	31	4	5	6	4	5	6
82	8	31	4	5	7	4	5	7
83	162	Sept. 1	5	6	7	4	5	6
84	46	1	5	6	8	4	5	7
85	84	2	6	7	8	4	5	6
86	16	2	6	7	9	4	5	7
87	10	3	7	8	9	4	5	6
88	46	3	7	8	10	4	5	7
89	16	4	8	9	10	4	5	6
90	6	4	8	9	11	4	5	7
91	10	5	9	10	11	4	5	6
92	4	5	9	10	12	4	5	7
93	4	6	10	11	12	4	5	6
94	13	7	11	12	14	4	5	7
95	20	8	13	14	16	5	6	8
96	7	8	13	14	17	5	6	9
Maximum						5	6	9
Minimum						2	3	4
Average						3.22	4.22	5.75

[1] Exact number of eggs not recorded.

Time of hatching.—According to the records in Table XXIV hatching of eggs of this brood began July 26 and continued until after the middle of September. A study of the table will show that hatching in greatest numbers was found to occur between August 1 and August 8.

THE THIRD BROOD OF LARVÆ.

Length of feeding period.—A total of 829 individual insects were kept under observation in order to obtain the records found in Table XXV. During the progress of the experiments the transforming larvæ were not separated from the wintering larvæ, which possibly influences the average length of the feeding period to some extent. The records given cover a variation in the length of the feeding period of from 15 to 56 days, or a range of variation of 41 days. The average length of the period was 26.55 days.

TABLE XXV.—*Length of feeding period of third brood codling-moth larvæ, Roswell, N. Mex., 1912.*

Date of hatching.	Number of individuals.	Length of feeding period in specified days, being the time from hatching of egg to leaving of fruit by larvæ.																																							Average days.	Minimum days.	Maximum days.	Total days.
		15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	56				
July 27	10				3		1		1	2		1	1		1																											25.1	18	28	251
28	16				3		3	5	3	1					1																											21.06	18	28	337
29	49				4			8	4	7	7	4	4		2	3	1	2												1	1	1									24.59	18	44	1,205
30	27							2	4	4	2	4	1	2			1	1	1			1		1		1		1					1								28.22	21	46	762
31	13					2		1	1	1	2	2				1	1	1						1																	25.15	19	37	327
Aug. 1	51			1		5	6	11	2	5	6			1	1	6	2	1		1	1		2																	24.01	17	36	1,225
2	55				1	7	14	8	6	1		7	2		2	5				1						1															22.8	18	39	1,254
3	42				2	4	5	5	2	11	1	3	1	2			1		1		1	3																			23.33	18	36	980
4	72			1	3	6	9	23	1	3	4	3	6	3	1		2				2	1						1		1			2	1						24.34	17	48	1,753
5	23		1	1	2	4	2	1		1	3	1	1		1		1	1		1		1																			21.17	16	34	487
7	46		1	3	9	7	4	7	4	1	4	2	1		1					1		1																			21.04	16	35	968
8	50	1	1	5	7	3	2	3	7	5	4	1	4	1	2	1	1			1				1																	22.06	15	37	1,103
9	19				2		2	3	3	1	1			1	2			1	1				1																			23.1	18	36	439
10	16				2	1	1	1	3	1		1		1	1	1				1		1		1																			24.93	18	37	399
11	10				6				3							1																									20.3	18	29	203
12	22				2	7		1	1	2		2			1	2	1	1		2																					23.68	18	33	521
13	17									3	5	5						2	1				1																			26.17	23	36	445
14	17		1	1	4	1		4	1	1		1			1	1			1																							21.53	16	32	367
15	10					2	2		1	2	1	1	1																													21.6	19	26	210
16	16				3	1	1				1	3		2		1					1	2		1																			25.37	18	37	406
17	23				2	1	3		2	6		1	2	2	2			1		1																							23.04	18	34	530
18	10				1	1	2	2	1	2			1																															21.3	18	26	213
19	14				1	1	3				2		1	1			2		2		1																							27.28	18	34	382
20	14							3	1	1	1			1	1			1		2	1	1		1																			28.28	21	38	396
21	9						3	2	1		1			1	1																													22.55	20	28	203
22	4									1	2	1																															24.0	23	25	96
23	8				3		2	1					1	1																													21.0	18	27	168
24	15						2	3	1			1	3		1	2		1		1																							25.2	20	33	378
25	12						1	1	1		1	4				1		2		1																							26.25	20	33	315
26	15						2	1	2	3	2					3		2																									24.86	20	31	373
27	16				1			1		6		1		1		1	1		3		1																							26.75	18	34	428
28	3					1			1					1																													23.0	20	27	69
29	11				1			1	1			1			3	3			1																									26.36	19	32	290
30	3									1	1		1																															24.33	23	27	74
31	8					1			1	2		1	2		1																													24.25	20	29	194
Sept. 1	4				1							1					1	1																											26.50	19	31	106
2	15		1		1		2	1	1		1	1		1	1			1	1	2	1																							34.6	16	34	369
3	9			1						1					1	1			1	1																							34.11	17	51	307
4	8												1		1		2	1		1																							32.25	26	45	266

TABLE XXV.—*Length of feeding period of third brood codling-moth larvæ, Roswell, N. Mex., 1912*—Continued.

Date of hatching.	Number of individuals.	Length of feeding period in specified days, being the time from hatching of egg to leaving of fruit by larvæ.																																							Average days.	Minimum days.	Maximum days.	Total days.
		15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	56				
Sept. 7	14												1	1	1	1	1			1	1			1		2			2					2					1	37.14	26	56	520
8	11													1		1	1	2			1				2								1		1	1				36.9	27	50	406
9	7								1		1					1	1						1		1						1						1			33.86	22	51	237
10	7																							1	1	1	1					1		1				1		42.71	37	52	299
11	3																						1			1				1										39.33	36	43	118
14	2							1															1																	28.5	21	36	57
16	3										1															1										1				37.66	24	50	113
	829	1	5	13	62	55	74	100	61	64	55	52	35	25	29	37	20	20	14	16	13	8	12	6	2	7	3	1	2	6	2	3	1	4	4	1	2	2	1	1	26.55	.....	.....	20,549

Larval observations with reference to the length of the cocooning period of this generation were limited to 26 individuals. Of this total the greatest number, 6, completed the construction of the cocoon in 4 days. The average length of this period was 6.48 days as compared with 5.24 days for the first brood and 5.16 days for the corresponding stage of the second generation. The records for the cocooning period for the third generation are found in Table XXVI.

TABLE XXVI.—*The making of cocoons of the third brood of the codling moth, Roswell, N. Mex., 1912.*

Date of leaving fruit.	Number of individuals.	Length of cocooning period in specified days.											Average days.	Minimum days.	Maximum days.	Total days.
		2	3	4	5	6	7	8	9	11	12	14				
Aug. 19	2	....	1	1	....	....	....	....	....	....	....	....	3.5	3	4	7
21	1	....	1	....	....	....	....	....	....	....	....	....	3.0	3	3	3
22	1	....	....	1	....	....	....	....	....	....	....	....	4.0	4	4	4
23	1	....	....	1	....	....	....	....	....	....	....	....	4.0	4	4	4
25	2	1	....	1	....	....	....	....	....	....	....	....	3.0	2	4	6
Sept. 1	2	....	....	....	1	....	....	1	....	....	....	....	6.5	5	8	13
2	2	....	....	....	....	1	1	....	....	....	....	....	6.5	6	7	13
3	2	....	....	1	....	....	....	....	1	....	....	....	6.5	4	9	13
4	1	....	....	....	....	....	....	....	1	....	....	....	9.0	9	9	9
5	2	....	....	....	1	....	....	1	....	....	....	....	6.5	5	8	13
6	3	....	....	....	....	....	1	1	....	....	1	....	9.0	7	12	27
7	3	....	....	....	....	....	....	1	1	1	....	....	9.3	8	11	28
8	1	....	....	1	....	....	....	....	....	....	....	....	4.0	4	4	4
9	1	....	....	....	....	....	....	....	....	....	....	1	14.0	14	14	14
10	2	....	....	....	1	....	....	....	....	....	1	....	8.5	5	12	17
	26	1	2	6	3	1	2	4	3	1	2	1	6.48	.....	.....	175

THE THIRD BROOD OF PUPÆ.

Time of pupation.—Observations on pupation in the rearing cages extended from August 19 until September 10, and experiments in this instance were conducted with only 17 individual insects. The small number available is due to the fact that large numbers of the larvæ of this brood proved to be wintering larvæ. Of those observed the greatest number having a specific period completed the pupal stage in 13 days. The average time for the entire number under observation was 14.94 days; maximum, 20 days; minimum, 11 days. The detailed results are shown in Table XXVII.

TABLE XXVII.—*Pupal stage of the third brood of the codling moth, Roswell, N. Mex., 1912.*

Date of pupation.	Number of individuals.	Length of pupal period in specified days, being the time from pupation to emergence of moth.								Average days.	Minimum days.	Maximum days.	Total days.
		11	12	13	14	15	17	19	20				
Aug. 19	1								1	20	20	20	20
23	1	1								11	11	11	11
Sept. 1	1	1								11	11	11	11
2	1		1							12	12	12	12
3	2			1		1				14	13	15	28
4	1					1				15	15	15	15
5	2				2					14	14	14	28
6	2			2						13	13	13	26
7	3			1				1	1	17.33	13	20	52
8	1					1				15	15	15	15
9	1							1		19	19	19	19
10	1						1			17	17	17	17
Total	17	2	1	4	2	3	1	2	2	14.94			254

THE THIRD BROOD OF MOTHS.

Time of emergence.—The limited number of moths with which the observations found in Table XXVIII were made is in proportion to the decreasing number of transforming larvæ as the season progressed. Emergence began September 3, and continued until September 28, thus covering a period of 25 days.

TABLE XXVIII.—*Time of emergence of moths of the third brood, Roswell, N. Mex., 1912.*

Date of emergence.	Number of moths.
Sept. 3	1
4	1
8	1
12	1
14	1
16	1
18	2
19	5
20	1
23	1
26	1
27	2
28	1
Total	19

LIFE-CYCLE OF THIRD GENERATION.

While the number of individual insects under observation to determine the length of life cycle of the third generation is notably smaller than in previous corresponding cases a sufficient number were observed to determine the length of the period very satisfactorily. The range of variation was found to be from 36 to 62 days, the greatest number, 3, having 48 days An average of 48.57 days is indicated for the third brood, as compared with 41.26 days for the corresponding period of the second brood, and 51.14 days for the first brood. (See Table XXIX.)

TABLE XXIX.—*Length of life cycle of the third generation of the codling moth, Roswell, N. Mex., 1912.*

Date of egg deposition.	Number of individuals.	Moths emerged in specified days from time of deposition of eggs of the same generation.															Average days.	Minimum days.	Maximum days.	Total days.
		36	40	41	44	45	46	47	48	49	50	51	52	54	55	60	62				
July 24	2			1			1											43.5	41	46	87
28	2								1								1	55.0	48	62	110
29	4					1				1			1			1		51.5	45	60	206
30	3	1									1	1						45.7	36	51	137
Aug. 2	3								2						1			50.3	48	55	151
3	1							1										47.0	47	47	47
4	2							1						1				50.5	47	54	101
9	1		1															40.0	40	40	40
10	1				1													44.0	44	44	44
	19	1	1	1	1	1	1	2	3	1	1	1	1	1	1	1	1	48.57	.....	.....	923

In Table XXX is brought together a condensed summary of records dealing with the codling moth of the third generation, showing the average length of the separate periods composing the life cycle of the insect. The average of the averages secured from the several stages recorded gives a total of 47.62. This sum when contrasted with the results as given in Table XXIX, shows a difference of but 0.95 days.

TABLE XXX.—*Summary records on the time of development of the codling moth of the third generation in its stages of egg, larva, and pupa, Roswell, N. Mex., 1912.*

Date of egg deposition.	Number of individuals.	Days of incubation.	Number of individuals.	Length of feeding larvæ.			Number of individuals.	Length of cocooning period.			Number of individuals.	Length of pupal stage.			Total length of life cycle.		
				Average days.	Minimum days.	Maximum days.		Average days.	Minimum days.	Maximum days.		Average days.	Minimum days.	Maximum days.	Number of individuals.	Average days.	Minimum days.	Maximum days.
July 23	2	10	2	19.5	18	21	2	4.0	4	4	.....	.....	.....	.....	.....	.....	.....	.....
24	3	15	3	19.0	18	21	2	3.5	3	4	2	15.5	11	20	2	43.5	41	46
26	2	12	2	18.5	17	20	2	3.5	3	4	.....	.....	.....	.....	.....	.....	.....	.....
27	2	12	2	25.0	25	25	2	5.5	5	6	.....	.....	.....	.....	.....	.....	.....	.....
28	3	18	3	24.0	23	26	3	11.0	7	14	2	15.5	12	19	2	55.0	48	62
29	4	24	4	21.3	20	23	4	10.0	8	12	4	14.3	11	20	4	51.5	45	60
30	3	18	3	22.0	16	26	1	8.0	8	8	1	13.0	13	13	3	45.6	36	51
Aug. 2	5	25	5	21.2	16	25	5	6.2	2	9	3	16.0	14	19	3	51.5	48	55
3	1	5	1	20.0	20	20	1	8.0	8	8	1	14.0	14	14	1	47.0	47	47
4	3	15	3	23.0	21	27	3	6.7	5	8	2	15.0	13	17	2	50.5	47	54
9	1	5	1	16.0	16	16	1	4.0	4	4	1	15.0	15	15	1	40.0	40	40
10	1	5	1	20.0	20	20	1	4.0	4	4	1	15.0	15	15	1	44.0	44	44
	30	164	30	21.23	.....	.....	27	6.7	.....	.....	17	14.9	.....	.....	19	47.61	.....	.....

Average length of incubation period in days, 5.46.

SEASONAL HISTORY OF THE CODLING MOTH DURING 1912.

In figure 4 a summary is given in graphical form to illustrate the progress of the development of the codling moth in the course of the entire season of 1912. The shaded portions are arranged to represent the periods in which the insect was prevalent in greatest numbers as determined by the average length of the several stages. The V-shaped characters appearing before the shaded portions show the

time at which it was possible for the stage to begin, while the dotted lines following the shaded areas represent a possible continuation of any particular stage as shown by observations which may, in many instances, represent extreme conditions.

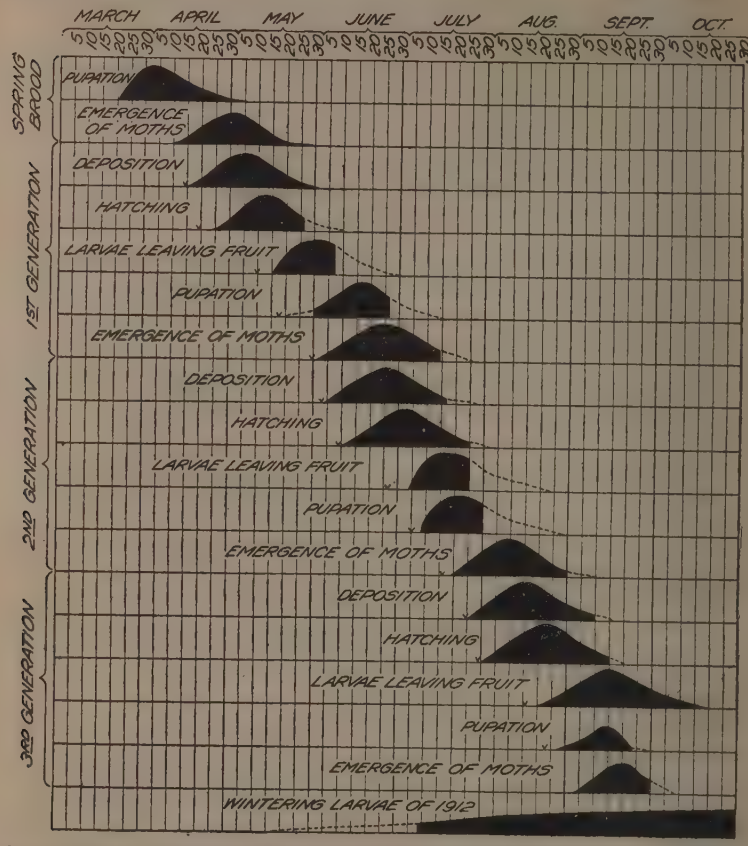

FIG. 4.—Diagram of the seasonal history of the codling moth for 1912, Roswell, N. Mex. (Original.)

BAND-RECORD LARVÆ OF 1912.

Throughout the season careful record was kept of larvæ collected from banded trees in orchards, and the results of these observations appear in Table XXXI.

Collections from field material began as early in the season as May 26, and continued regularly every three days throughout the season. In this way a total of 9,400 larvæ were collected, of which number 6,922 transformed and emerged as moths. Of the 6,922 moths which comprise the total emergence for both seasons, 4,636 moths appeared during the season of 1912, and 2,286 moths emerged from

overwintering larvæ in the spring of 1913. Of all the larvæ collected throughout the season of 1912, moths from the transforming larvæ composed 49.32 per cent, almost one-half of the entire number. Moths emerging from wintering larvæ comprised 24.32 per cent of the total number, while 26.36 per cent of the larvæ died without transforming.

TABLE XXXI.—*Band records for the codling moth for the season of 1912, Roswell, N. Mex. Emergence records completed, 1913.*

Collection No.	Date of collecting.	Number of larvæ collected.	Number of moths emerged, 1912.	Number of moths emerged, 1913.	Total number moths, 1912-13.	Number of dead.	Per cent of dead.
1	May 26	16	5	.....	5	11	68.7
2	29	59	44	.....	44	15	25.4
3	June 1	89	63	.....	63	26	29.2
4	4	88	77	.....	77	11	12.5
5	7	171	167	1	168	3	1.75
6	10	88	88	.....	88	.....	0
7	13	72	66	1	67	5	6.94
8	16	90	73	.....	73	17	18.88
9	19	62	57	.....	57	5	8.06
10	22	33	27	1	28	5	15.1
11	25	37	34	.....	34	3	8.1
12	28	45	41	.....	41	4	9.75
13	July 1	32	25	.....	25	7	21.87
14	4	39	22	.....	22	17	43.6
15	7	66	57	1	58	8	12.1
16	10	179	162	.....	162	17	9.5
17	13	303	248	.....	248	55	18.1
18	16	451	372	.....	372	79	17.5
19	19	411	368	.....	368	43	10.46
20	22	609	530	1	531	78	12.8
21	25	678	596	7	603	75	11.06
22	28	623	483	8	491	132	21.18
23	31	399	354	9	363	36	9.02
24	Aug. 3	360	251	23	274	86	23.9
25	6	235	159	35	194	41	17.4
26	9	261	131	53	184	77	29.5
27	12	232	73	86	159	73	31.46
28	15	142	28	74	102	40	28.17
29	18	110	20	59	79	31	28.18
30	21	88	12	49	61	27	30.68
31	24	86	2	55	57	29	33.72
32	27	88	1	51	52	36	40.9
33	30	106	.....	54	54	52	49.05
34	Sept. 2	133	.....	79	79	54	40.6
35	5	127	.....	84	84	43	33.8
36	8	179	.....	90	90	89	49.7
37	11	207	.....	122	122	85	41.06
38	14	306	.....	175	175	131	42.8
39	17	239	.....	133	133	106	45.19
40	20	283	.....	144	144	139	49.1
41	23	201	.....	135	135	66	32.8
42	26	212	.....	111	111	101	47.64
43	29	242	.....	106	106	136	56.2
44	Oct. 2	112	.....	59	59	53	47.3
45	5	180	.....	88	88	92	51.1
46	8	149	.....	99	99	50	33.55
47	11	149	.....	72	72	77	51.7
48	14	67	.....	52	52	15	22.18
49	17	61	.....	45	45	16	26.2
50	20	104	.....	61	61	43	41.34
51	23	35	.....	18	18	17	48.56
52	26	39	.....	23	23	16	41.02
53	29	24	.....	19	19	5	20.83
54	Nov. 1	3	.....	3	3	0	0
		9,400	4,636	2,286	6,922	2,478	.....

	Per cent.
Moths from transforming larvæ composed	49.32
Moths from wintering larvæ composed	24.32
Dead larvæ composed	26.36
Total	100.00

The occurrence of the larvæ of the codling moth in orchards as shown by results of the band records is graphically described by means of curves in figure 5. From this figure it may be deduced that the greatest number of larvæ of the first brood leaving the fruit was found to occur about June 7. Larvæ of the second brood appeared under the bands in greatest numbers in the neighborhood of July 25, or practically 50 days after a maximum was found in the first brood. With reference to the third brood it will be noted that the greatest number of larvæ were found September 14, which is just 51 days following the corresponding stage of the second generation. These figures agree very well, however, with the conclusion

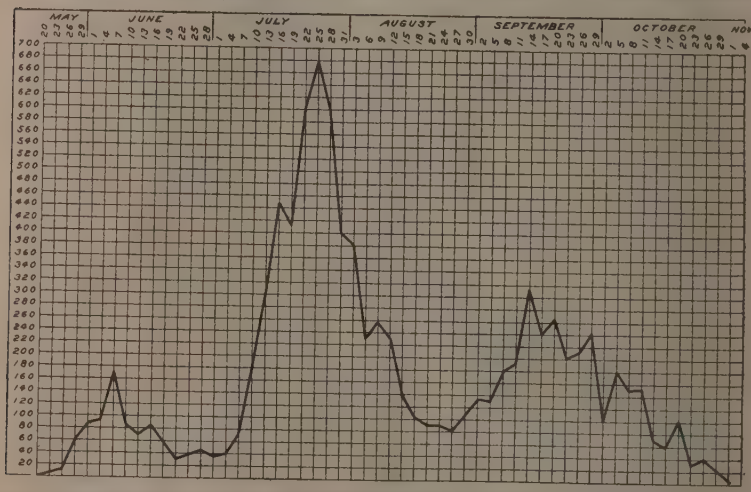

FIG. 5.—Curve showing occurrence of the codling-moth larvæ under bands on apple trees, Roswell, N. Mex., 1912. (Original.)

drawn from records obtained in the rearing shelter with insects in confinement. (See summary tables on the different generations.)

SEASONAL-HISTORY STUDIES OF 1913.

The results of the 1913 life-history studies of the codling moth do not, in general, differ greatly from those obtained the previous year. They are, however, somewhat more complete and detailed in certain respects, and are therefore more satisfactory, for the observations during this season were conducted under more favorable conditions.

SOURCE OF REARING MATERIAL.

Rearing material consisted of wintering larvæ of 1912, kept in an outside shelter and subjected to existing weather conditions, and other material which could be considered quite normal and from which reliable conclusions could be drawn.

The larvæ were from both band-record material and the results of propagation of the several broods in the rearing shelter.

Many of the larvæ had been kept over winter in pieces of decayed wood and in strips of corrugated paper. These formed a suitable means of seclusion for the wintering larvæ and were kept in glass jars with easily removable tops, from which the emerging moths could be taken without difficulty.

METHOD OF PROCEDURE.

Immediately following emergence the moths were transferred to large glass receptacles covered with white cheesecloth or muslin, and there allowed to proceed with mating and egg deposition. Fresh pear foliage was placed within these receptacles daily, and while the majority of the eggs were deposited on the leaves and stems, frequently the sides of the jar would be quite thickly studded with eggs when the number of females per jar was excessive.

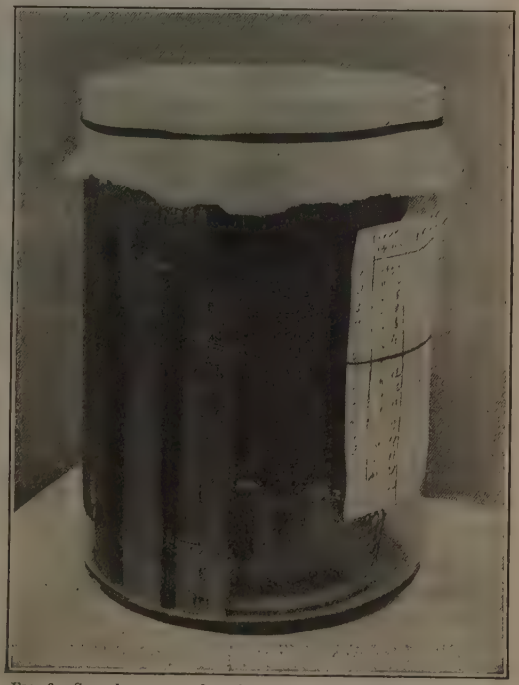

FIG. 6.—Sample cage used to determine feeding period of codling-moth larvæ. (Hammar.)

The leaves and the twigs upon which the eggs had been deposited were removed from the containers daily and placed in a glass jar in which a holder or basket made from woven wire of fine mesh, and containing a number of medium-size apples, had been inserted. Only unsprayed fruit was used for this purpose, and care was exercised to make certain that no fruit was used that had been previously entered by larvæ. When the period of incubation was over the leaves and the twigs were removed, because the presence of the leaves frequently offered a place for cocooning and pupation, which was not desirable. In figure 6 a sample cage is illustrated, and the strips of wood which were prepared and dropped in to provide acceptable hiding places during cocooning and pupation are also shown.

In order that observations might be made during the period of cocooning and at the time of pupation without disturbing the specimens in their normal manner of procedure, small strips of wood with slight partitions between them were used, held together by paper clips bent at a convenient angle. Over the partitions was pasted a thin film of mica with a sprinkling of fine sawdust underneath. This device, described in previous publications of the bureau, proved to suffice throughout the period of experimentation.

Figure 7 is an illustration of the strips of wood used.

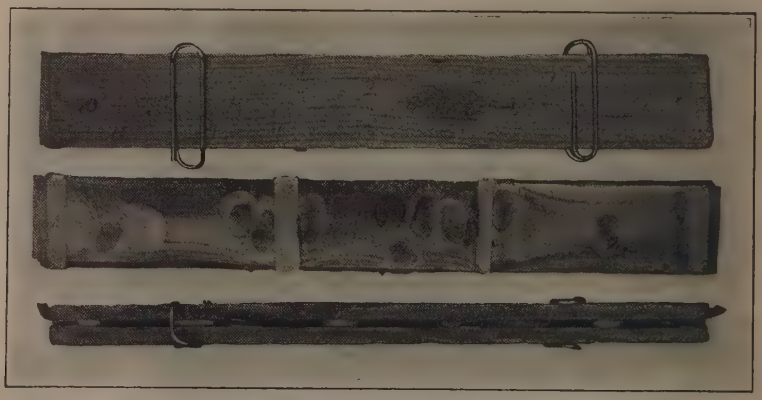

FIG. 7.—Device used to obtain pupal records of the codling moth. (Hammar.)

THE SPRING BROOD.

SPRING BROOD OF PUPÆ.

Time of pupation.—The first record of pupation of overwintering larvæ took place March 23, and from that date pupation continued more or less regularly for a period of 51 days, the last pupation recorded occurring on May 13.

Length of pupal stage.—The length of the pupal period of the spring brood has a range of from 12 to 36 days, the majority of the individuals, however, completing the stage after 26 days had elapsed. The average for the entire time is found to be 22.97 days. (See Table XXXII.)

TABLE XXXII.—*Pupal period of the spring brood of the codling moth, Roswell, N. Mex., 1913.*

Date of pupation.	Number of individuals.	Length of pupal period in specified days.																					Average days.	Maximum days.	Minimum days.	Total days.
		12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30	31	32	33	34	36				
Mar. 23	4															2	2								26.5	27	26	106
24	6															4									28.3	34	26	170
25	7														1	3	1	1		1	1		1		27.0	31	25	189
26	7												1	2					1		1	1		1	29.3	36	24	205
27	3											1	1							1					25.3	31	22	76
28	12										1	8	1	1	1										22.4	25	21	269
29	23										5	6	4	8											22.7	24	21	521
30	20									1		2	14			2			1						23.4	30	20	468
31	17									2	1	3			5	6									24.0	26	20	408
Apr. 1	19						1	2	1	1	6			2	2	2		2							22.3	28	17	424
2	29						1	1		2			1	9	5	8	2								24.2	27	17	701
3	18			1		1	1	2	1			1	3			4	3	1							22.6	28	14	406
4	5				1			1					1			1	1								21.8	27	15	109
5	7										1		2		1	2				1					25.0	31	21	175
6	2								1					1											21.5	24	19	43
7	5		1										3		1										21.4	25	13	107
8	7	2							1				2	1	1										19.7	25	12	138
9	3		1						1				1												18.3	23	13	55
10	1															1									26.0	26	26	26
11	2	2																							12.0	12	12	24
12	2		1										1												18.0	23	13	36
13	1				1																				15.0	15	15	15
14	2					1				1															18.0	20	16	36
16	3	1									2														18.0	21	12	54
17	1										1														21.0	21	21	21
18	1								1																19.0	19	19	19
19	3	1							1		1														17.3	21	12	52
20	1							1																	18.0	18	18	18
27	1								1																19.0	19	19	19
30	1					1																			16.0	16	16	16
May 8	1								1																19.0	19	19	19
13	1				1																				15.0	15	15	15
	215	6	3	1	3	3	3	7	9	7	18	21	34	23	19	35	9	4	2	3	2	1	1	1	22.97	.....	.....	4,940

SPRING BROOD OF MOTHS.

Time of emergence.—The emergence of moths of the spring brood was found to begin as early as April 7 and to continue more or less regularly until the first part of June. However, a maximum emergence was found to occur in the 10-day period between April 17 and 27, in which a total of 1,334 moths emerged. The emergence during this period represents 58.33 per cent of the entire number which emerged during 1913, covering a period of 57 days. Further examination of Table XXXIII will show that of 7,343 larvæ, the entire number collected, a sum total of 5,216 moths emerged, being equivalent to 71.04 per cent of the larvæ It may be noted in this connection that 56.19 per cent of the moths emerged during 1912, while 43.81 per cent emerged in the spring of 1913.

TABLE XXXIII.—*Time of emergence of codling moths of the spring brood, Roswell, N. Mex., 1913. Larvæ from band-record material of 1912.*

| Date of collection. | Number of larvæ. | Number of moths, 1912. | April. | | | | | | | | | | | | | | | | | | | | | | | May. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | June. | Number of moths, 1913. |
|---|---|---

The time and rate of emergence of the spring brood of moths are illustrated diagrammatically in figure 8.

Egg deposition.—The records on egg deposition by individual moths of the spring brood are somewhat limited, because of the 34 females isolated in this connection only 9 gave results worthy of record, as shown in Table XXXIV.

From a total deposition of 257 eggs it will be noted that the maximum deposition per female was 91 eggs, while the average number per moth was approximately 28 eggs. On an average 7.33 days

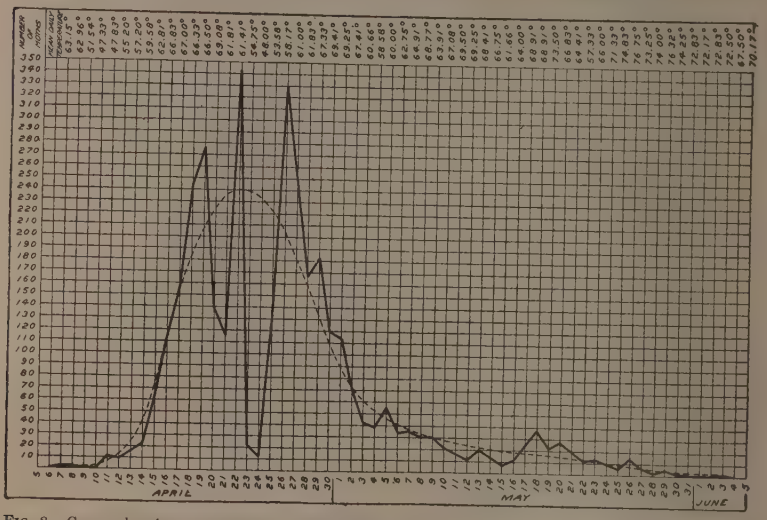

FIG. 8.—Curve showing emergence of codling moths of the spring brood, Roswell, N. Mex., 1913. (Original.)

elapsed from time of emergence to first oviposition. The maximum time, however, was 12 days; the minimum, 3 days. The length of the period of oviposition for the 9 individuals under observation averaged 5.55 days; the maximum was 10 days; minimum, 1 day. On an average the moths in confinement lived 12.88 days, which is somewhat longer than the corresponding period for the female moths of the spring brood of 1912, which gave an average length of life of 8.47 days. In 1912 the maximum length of life of female moths of the spring brood was 22 days; in 1913 the corresponding period was 20 days.

TABLE XXXIV.—*Egg deposition by individual codling moths of the spring brood, Roswell, N. Mex., 1913.*

Observation No.	Date of emergence of moths.	Date of oviposition and number of eggs deposited. May.																					Death of moth.	Total number of eggs per moth.	Length of period before first oviposition.	Period from first to last oviposition.	Period from emergence to last oviposition.	Total length of life of moth.
			2	3	4	6	7	8	9	10	12	13	14	15	18	22	24	25	26	27	29	30			*Days.*	*Days.*	*Days.*	*Days.*
1	April 28						1			10		9	3	4									May 18	27	9	9	17	20
2	28				2	1		19	2	3	2	3											15	32	6	10	15	17
3	28									2		3	5										15	10	12	5	16	17
4	28									11	6	20											14	37	12	4	15	16
5	28	17																					2	17	3	1	3	4
6	28		1	1		3		12															8	17	4	7	10	10
7	May 9														10	7							22	17	9	5	13	13
8	20																26	37	3	10	15		29	91	4	5	9	9
9	20																			1	7	1	30	9	7	4	10	10
Total		17	1	1	2	4	1	31	2	26	8	35	8	4	10	7	26	37	3	11	22	1		257				

Summary.	Average.	Maximum.	Minimum.
Number of days from emergence of moth to first oviposition	7.33	12	3
Number of eggs deposited by each female	28.5	91	9
Length of oviposition period in days	5.55	10	1
Number of days from emergence of moth to last oviposition	12.0	17	3
Length of life of moth in days	12.88	20	4

NOTE.—In this instance 34 individual moths were isolated of which only 9 gave results worthy of record. Moths confined in jelly glasses with pear foliage. Fresh moistened foliage placed in jar daily. Moths confined in numbers in large jars 2 days prior to isolation to insure mating.

THE FIRST GENERATION.

FIRST BROOD OF EGGS.

Time of deposition.—The earliest deposition of eggs of the first brood in rearing cages occurred April 16, and more or less regular depositions continued for a period of 45 days. The time for the occurrence of a maximum deposition, however, would appear to be near the latter part of the period, and the irregularities previously noticeable are probably due to weather conditions.

Length of incubation.—A total of 212 observations made in this connection show a range of variation in the length of the incubation period of 4 to 11 days. A decrease in the length of the period was somewhat noticeable as the season advanced, although exceptions occur. An average period of 5.96 days is found for the entire number. These results are shown in Table XXXV.

TABLE XXXV.—*Time of incubation of eggs and length of feeding period of larvæ of the first generation of the codling moth, Roswell, N. Mex., 1913.*

Date of egg deposition.	Number of individuals.	Days of incubation.	Length of feeding period of larva in specified days.															Average days.	Minimum days.	Maximum days.	Total days.
			16	19	20	21	22	23	24	25	26	27	28	29	30	31	32	38				
Apr. 16	4	11												1	1		1	1	32.2	29	38	129
19	1	10											1						28.0	28	28	28
28	2	7						1	1										23.5	23	24	47
29	12	7				1		2	2	1	4	1	1						24.9	21	28	299
May 1	12	8			2	3	1	2			2	2							23.08	20	27	277
2	2	8			1				1										22.0	20	24	44
3	9	7			1		1	2	2	2	1								23.5	20	26	212
5	1	6									1								26.0	26	26	26
7	3	6		1		1	1												20.7	19	26	62
8	7	6		1	2			2	2										21.8	19	24	153
9	3	6					2		1										22.7	22	24	68
10	5	5					2	1	1				1						23.8	22	28	119
11	6	5				1	1					1	2			1			26.1	21	31	157
12	7	5								2		2			2	1			27.8	25	31	195
13	16	5		1	1		3			1	3	4		3					25.1	19	29	403
14	8	5							2		2	3				1			26.5	24	31	212
19	8	5								2	3	1				1	1		27.2	25	32	218
21	7	6					1		1	2	2			1					25.3	22	29	177
23	2	4						1					1						25.2	23	28	51
24	7	4					3		1	1	1	1							24.0	22	27	168
25	10	4				1	1	2	1	2	1	2							24.3	21	27	243
26	12	5				1	2	2	3	2		1	1						24.0	21	28	288
27	7	5		1			2	1	3										22.29	19	24	156
28	20	5				1	1	1	9	3	5								24.4	21	26	487
29	15	6			2	1	2	2	4	1	1	2							23.4	20	27	352
30	13	5		1			5	3	2		1	1							23.0	19	27	299
31	13	5	1			1	1	5	2		1		1	1					23.5	16	29	305
	212		1	5	9	11	29	27	38	19	28	21	8	6	3	4	2	1	24.45			5,175

Total days' incubation for all eggs, 1,194; average incubation period, 5.96 days.

THE FIRST BROOD OF LARVÆ.

Length of feeding period.—The length of the feeding period of larvæ of this brood covered a range of 22 days, the greatest number, 38, having completed the period in 24 days. The maximum time is 38 days, and the minimum period 16 days. The average period for the entire 212 individuals is found to be 24.45 days, which is 2.93 days greater than the corresponding period for the first brood in 1912.

Feeding period of wintering larvæ.—It is generally conceded that wintering larvæ experience a longer feeding period than those transforming the same season. In Table XXXVI it is shown that of 15 wintering larvæ of the first brood a maximum period of 31 days was noted; a minimum period of 22 days, with an average period of 25.13 days. This is an increase of but 0.68 day over the feeding period of the transforming larvæ of this brood.

TABLE XXXVI.—*Length of feeding period of wintering codling-moth larvæ of the first brood, Roswell, N. Mex., 1913.*

Observation No.	Date of—		
	Hatching.	Leaving the fruit.	Days feeding.
1	May 9	June 5	27
2	9	5	27
3	15	6	22
4	16	12	27
5	16	16	31
6	18	14	27
7	27	19	23
8	28	21	24
9	28	22	25
10	28	23	26
11	28	24	27
12	29	20	22
13	June 2	26	24
14	4	27	23
15	4	July 1	27

Maximum days, 31; minimum days, 22; average, 25.13; average for transforming, 24.45.

Percentage of wintering larvæ.—Of the larvæ of the first brood under observation 15 of the 212 proved to be wintering larvæ, while 197 transformed the same season, showing as a result that only 7.16 per cent of the larvæ of this brood proved to be wintering larvæ.

Larval life in the cocoon.—The larval life in the cocoon is here broadly considered to be the time necessary for the making of the cocoons, and is recorded as the time elapsing between the date the larvæ leave the fruit and the time of pupation. The wintering larvæ of the first brood are not included here, since these remain in the larval stage until the following spring. In Table XXXVII are found the results of 193 observations which show a variation of from 2 to 21 days, and an average period of 5.7 days.

TABLE XXXVII.—*The making of cocoons of the first brood of the codling moth, Roswell, N. Mex., 1913.*

Date of egg deposition.	Number of individuals.	Length of cocooning period in specified days, being the time from leaving the fruit to the time of pupation.														Average days.	Minimum days.	Maximum days.	Total days.
		2	3	4	5	6	7	8	9	10	11	12	13	14	15	21				
Apr. 16	4					1		1		1		1					9.0	6	12	36
28	1				1												5.0	5	5	5
29	12			6	4	2											4.6	4	6	56
May 1	10		4	2	3	1											4.1	3	6	41
2	2	1		1													3.0	2	4	6
3	9		1	2	3	3											4.8	3	6	44
5	1						1										7.0	7	7	7
7	3		1	2													3.6	3	4	11
8	7		1	2			2	1			1						6.2	3	11	44
9	2			1		1											5.0	4	6	10
10	5			1		3	1										5.8	4	7	29
11	4				1	2	1										6.0	5	7	24
12	6								1	1		2		1	1		12.0	9	15	72
13	14				1	3	3			1	1		3	1		1	9.09	5	21	139
14	8			1		2	3	1			1						7.0	4	11	56
19	8	1	1		1	3	1	1									5.3	2	8	43
21	7			1	5	1											5.0	4	6	35
23	1			1													4.0	4	4	4
24	3				2	1											5.3	5	6	16
25	8		1	3	1			1					1	1			6.9	3	14	55
26	13		2	8	3												4.1	3	5	53
27	7	1		5	1												3.8	2	5	27
28	19			10	7		1								1		5.1	4	15	97
29	15		2	6	5	2											4.4	3	6	67
30	11			10	1												4.1	4	5	45
31	13			2	8		1	2									5.5	4	8	71
	193	3	13	64	47	25	14	7	1	3	3	3	4	3	2	1	5.7			1,093

Length of pupal period.—To determine the length of time occupied from the date of pupation until the emergence of moths, 148 individual insects were kept under observation. Of this number 36 moths emerged in 11 days, while the range of the pupal period was 16 days. The average time for the entire 148 pupæ was 11.76 days; maximum, 21 days; minimum, 5 days. These results are shown in Table XXXVIII.

TABLE XXXVIII.—*Pupal period of the first brood of the codling moth, Roswell, N. Mex., 1913.*

Date of egg deposition.	Number of individuals.	Length of pupal stage in specified days.															Average days.	Minimum days.	Maximum days.	Total days.
		5	6	7	8	9	10	11	12	13	14	15	16	17	19	21				
Apr. 16	2										1		1				15.0	14	16	30
29	12							1		2	4	5					14.0	11	15	168
May 1	8									1	4	3					14.3	13	15	114
2	2											2					15.0	15	15	30
3	6									2	2	2					14.0	13	15	84
7	2										1	1					14.5	14	15	29
8	6							1	2		1	1				1	14.1	11	21	85
9	2										2						14.0	14	14	28
10	3							1	1	1							12.0	11	13	36
11	2									2							13.0	13	13	26
12	6	1	1	3								1					7.8	5	15	47
13	5						1			1				2	1		15.2	10	19	76
14	8						2	3	1	1					1		12.1	10	19	97
19	6				1	3	1	1									9.3	8	11	56
21	4						2	2									10.5	10	11	42
23	1							1									11.0	11	11	11
24	2			1		1											8.0	7	8	16
25	6					1	2	3									10.3	9	11	62
26	12				1		5	4	1				1				10.8	8	16	130
27	5					1	2		1				1				11.4	9	16	57
28	16					1	8	6	1								10.4	9	12	167
29	14				1		5	7			1						10.6	8	14	149
30	10					3		3	2		1		1				11.4	9	16	114
31	8						4	3	1								10.6	10	12	85
	148	1	1	4	3	10	32	36	10	10	17	15	4	2	2	1	11.76			1,739

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Time of emergence.—The records on the emergence of moths of the first brood are found in Table XXXIX, showing that from a total of 2,588 larvæ collected from banded trees between May 20 and June 22 there emerged 2,219 moths. Thus 85.75 per cent of the larvæ collected in this way proved to be transforming larvæ of the same season. Actual emergence covered a period extending from June 3 until July 10, while the greatest number of moths emerging on any specified day appeared on June 15, when 261 individuals emerged. A maximum emergence occurred in the four-day period from June 15 to June 19, when there emerged 882 moths, which constituted practically 40 per cent of the entire emergence covering a period of 37 days.

TABLE XXXIX.—*Time of emergence of codling moths of the first brood from larvæ collected from banded trees and kept in cages, Roswell, N. Mex., 1913.*

Date of collection.	Number of larvæ.	June—																								July—									Number of moths.
		3	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9	10	
May 20	5	1			1									1																						3
23	40		4	17	6	3	4		3		1										1																39
26	140			4	26	11	27	13	28	14	3	2	1																							129
29	833							2	13	27	77	259	133	77	94	20	6	4	2	1	1	2	1										1				661
June 1	517								1		1	1	22	57	94	178	63	20	21	2	1	2							1								464
4	320												3	1		1	11	34	76	87	43	9	3	3		2										273
7	249																			8	102	83	25	7	4	1										220
10	130																					4	53	36	17	2	1										113
13	89																							7	38	26	3	4	4								82
16	76																									3	9	31	21	3	3						70
19	95																										1	2	14	23	28	5	2	1	1		77
22	94																										1		1		7	20	32	24	1	1	1	88
Total	2,588	1	4	21	33	14	31	13	33	28	31	80	261	159	135	128	199	80	58	99	99	147	100	82	53	59	34	15	37	41	26	38	26	34	25	2	1	1	2,219

The emergence of moths of the first generation is shown in the diagram appearing as figure 9. The larvæ used in these experiments were collected regularly from May 20 until June 22 from banded trees, and the curve in this figure represents the sum total of daily emergence from these larvæ.

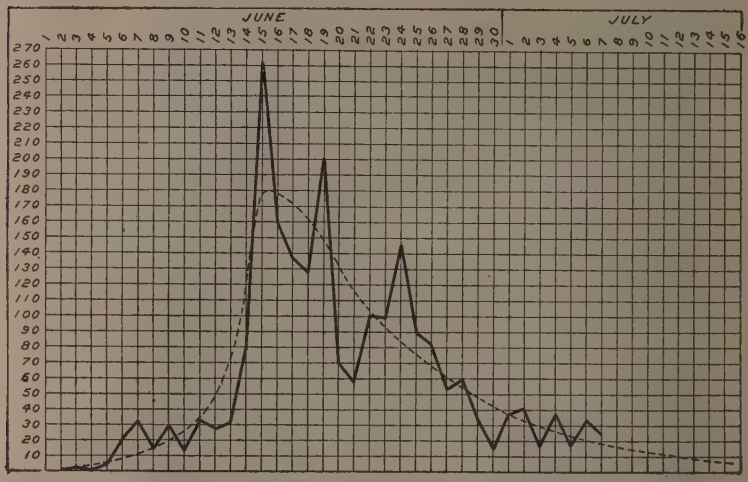

FIG. 9.—Curve showing emergence of codling moths of first brood, Roswell, N. Mex., 1913. (Original.)

LIFE CYCLE OF FIRST GENERATION.

The entire length of time required for the first generation of the codling moth to pass through the several stages and reach the adult stage is totaled in Table XL.

TABLE XL.—*Length of life cycle of first generation of codling moths from time of egg deposition to emergence of moth, Roswell, N. Mex., 1913.*

Date of egg deposition.	Number of individuals.	Moths emerged in specified days from time of deposition of eggs of the same generation.																		Average days.	Minimum days.	Maximum days.	Total days.
		39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	56	60	65				
Apr. 16	2																			2	65.0	65	65	130
29	12						1			2		1	1	2		2	3				50.6	54	44	607
May 1	8								3		1		2	2							48.5	51	46	388
2	3							1						1		1					49.6	53	45	149
3	5							1					2	2							49.4	53	45	247
7	3					1			1	1											45.3	47	43	136
8	6					1		1				1	2	1							48.0	51	43	288
9	2										2										48.0	48	48	96
10	3									2		1									47.7	49	47	143
11	2							1						1							48.0	51	45	96
12	6													1	2		1	1	1		54.1	60	51	325
13	5									1			1		1	1	1				51.2	54	47	256
14	8								1			1	2	2	1			1			50.6	56	46	405
19	6							1	3			1	1								47.0	50	45	282
21	4								1	1	1			1							48.0	51	46	192
23	1									1											47.0	47	47	47
24	2	1	1																		39.5	40	39	79
25	6					4							2								45.3	50	43	272
26	12		1	1	3	1		3	2		1										43.9	48	40	525
27	5	1	1	1		1	1														41.4	44	39	207
28	16					3	5	5	2	1											44.3	47	43	710
29	14		2		1	1	3	2	2	1	2										44.2	48	40	622
30	10		2		2	2	2	1		1											43.0	47	40	430
31	8		2			2	1				1	1	1								44.6	50	40	357
	149	2	9	2	6	16	13	16	15	11	8	6	14	13	4	4	5	2	1	2	46.91	.....	.....	6,990

Of 149 individual insects under observation, 16 were found to have a total life cycle of 45 days. Two insects required 65 days and represent a maximum time for the brood; two specimens were found to have completed the previous stages in 39 days, which is considered the minimum time. An average time of 46.91 days prevails, and a range of variation of 26 days is noted.

EGG DEPOSITION BY INDIVIDUAL MOTHS.

Mating.—Records of egg deposition by individual females in captivity have proven of especial interest in connection with these studies of the codling moth. Records on egg laying and mating of the codling moth have been very limited, and statements by earlier investigators have been largely speculative estimates. The lack of information is due to the difficulty of getting moths to deposit eggs in a state of captivity, especially when the individual insects are isolated. Although many thousand moths have been under observation it has been only in rare instances that moths have been found in copula. In 1913 these observations were made for the first brood of moths, and in Table XLI these observations are listed under numbers 21, 23, and 48. The moths in connection with observation No. 21, both male and female, emerged June 22 and were found mating at 10 a. m. on June 24. Eggs were deposited the same day. The individuals in connection with observation No. 23, both male and female, emerged June 24 and mated on June 27 at 8 a. m. Eggs were deposited during the following night. The moths referred to as observation No. 48, male and female, emerged July 6 and were found in copula on July 7 at 9 a. m. and remained so until 2 p. m. of the same day. The wings of this female were not fully expanded, and this may account for the long mating, the moth when dead still having the abdomen distended with eggs. Since the moths are very inactive during the heat of the day it is very probable that mating takes place at twilight, during warm nights, and in the morning. Mating also very likely takes place under natural conditions shortly after the moths take flight after emergence, and as the sexes encounter each other.

Egg deposition.—In the course of these investigations it was noted that eggs were deposited in abundance when moths were confined together in numbers in large jars. This fact led to further experimentation and male and female moths were isolated, being removed from the larger jars after two days' confinement, and placed in smaller jars for observation of egg deposition. The moths were first fed on diluted sugar water placed on a small piece of sponge, but this method invariably made the jars sticky and in consequence the moths died prematurely. Later dried pear leaves were placed in each jar, each leaf being daily moistened with pure water. The dried leaves, being black, showed the presence of the white eggs; the most of the eggs, however, were placed on the side of the glass jars.

In all, 141 female moths were taken from the larger jars and isolated, some of these being accompanied by males and others being without males. Of these, 48 furnished oviposition records, as stated in Table XLI, while 93 of them, or two-thirds of the number, failed. Of the latter a few eggs resulted, though as far as observed they were all nonfertilized, one or two being deposited a day, though the greater number of the moths did not oviposit at all.

The confining of the moths in this manner results in a very abnormal condition for the insect, and markedly different results may occur normally in orchards. For instance, it was found that most of the moths died before all the eggs had been deposited, the dead females often containing an abundance of fully developed eggs. Thus the averages here obtained are unquestionably far below what normally occurs in the field. It is also likely that in many cases egg laying was delayed. The results, however, show what is possible in this connection and what might happen even under conditions considerably removed from the normal with reference to the extent of egg deposition and length of life of moths.

On an average the first eggs were deposited three days after the emergence of the moths, while a maximum length of time of 6 days and a minimum time of 2 days prevailed. The greatest number of eggs produced by a single female was 200, and the results averaged 80.2 eggs for the 48 females under observation. The moth listed under observation No. 8, in Table XLI, escaped before the test was concluded and might have deposited more eggs, as the abdomen was still quite distended with eggs. A total of 192 eggs were found in the jar.

As there exists a considerable degree of variation in the size of moths also, there probably is to be found variation in the number of eggs laid by each female. Moths of the spring brood are, as a whole, smaller than moths of the first and second broods, and probably are less productive than the latter.

In general the moths began ovipositing 3 days after emergence, although the shortest period was 2 days. The number of eggs deposited per female per day varied from 1 to 96 and averaged 20 eggs per day for the 48 moths. Normally this number would be greater. In confinement moths often ceased ovipositing for a day during the period of deposition, and frequently only one egg was deposited during 24 hours, although previously and later numerous depositions were made. On an average, oviposition extended over 5.7 days, and the moths died on an average 2 days after final oviposition, although sometimes death occurred the same day. In 1912, deposition records obtained with moths of the first brood show that the average extent of the deposition period was 4.45 days. The average length of time from the date of emergence to that of the last oviposition was almost identical for the corresponding broods of the two seasons, there being a difference of but 0.55 day.

TABLE XLI.—*Egg deposition by individual codling moths of the first brood, Roswell, N. Mex., 1913.*

Moth No.	Date of emergence of moths.	Date of oviposition and number of eggs deposited.																									Death of moth.	Total number of eggs per moth.	Length of period before first oviposition.	Period from first to last oviposition.	Period from emergence to last oviposition.	Life of moth after last oviposition.	Total length of life of moth.	Number of days on which oviposition occurred.	Average number eggs per oviposition per female.
		June—												July—																					
		18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13									
																														Days.	*Days.*	*Days.*	*Days.*	*Days.*		
1	June 13	8	6	8	12	15	19	5																				June 26	73	5	7	11	2	13	7	10.4
2	15		6			1		10		4	5	1	7	3														July 1	37	4	12	15	1	16	8	4.6
3	17				1	5	3	4		2	1	3		8														4	27	4	10	13	4	17	8	3.4
4	17		1	20	14	2	8																					June 26	45	2	5	6	3	9	5	9.0
5	17		10	44	1	28																						24	83	2	4	5	2	7	4	20.75
6	17		22	60		11																						25	93	2	4	5	3	8	5	31.0
7	17		22		2	2	1			1																		30	28	2	8	9	4	6	5	5.6
8	17		21	50	30	2	12	29	25	23																			192	2	8	9			8	24.0
9	17					5	26	5	2	15	23																	July 2	76	5	6	10	5	15	6	12.6
10	20								5	26																		June 30	31	5	2	6	4	10	2	15.5
11	20							61	16	1																			27	78	4	3	6	1	7	3	26.0
12	20							27	23	28	30	29	15	10	11													July 3	173	4	8	11	2	13	8	21.6
13	20							51	18																			June 27	69	4	2	5	2	7	2	34.5
14	22								23	19																		27	42	3	2	4	1	5	2	21.0
15	22									1	22	2																29	25	4	3	6	1	7	3	8.3
16	22							3	23	47	1	41	6	5	5	3												July 7	134	2	9	10	5	15	9	14.8
17[1]	22							27			47	2	2																78	2	6	7			4	19.5
18	22									1	24		2	15	10													2	52	4	6	9	1	10	5	10.4
19	22							65	3	42	32	34	6	18														2	200	2	7	8	2	10	7	28.5
20	22							62	18	4																		6	84	2	3	4	10	14	2	28.0
21	22							23	31	7	30		1	12														3	112	2	7	8	3	11	6	18.7
22	22							42	4	37	2	9	4	2	3													3	103	2	8	9	2	11	8	12.8
23	24										6																	June 30	6	3	1	3	3	6	1	6.0
24[1]	24											96																	96	4	1	4			1	96.0
25	24										51	12																July 5	63	3	2	4	7	11	2	31.5
26	24										20	3	49	14	41	35		18										6	180	3	8	10	2	12	7	25.7
27	24										1	1	6	15	2	11	3	22										6	61	3	8	10	2	12	8	7.6
28	24											14	26	25	2	5	28	2										6	102	4	7	10	2	12	7	14.5
29	24											3	5				10	1		39								10	58	4	9	12	4	16	5	11.6
30	24											1	1		7		1	18	5	30	18							9	81	4	10	13	2	15	8	10.1
31	27															3	2	19	7	1				1				11	33	5	9	13	1	14	6	5.5
32	27												1			1			5		1	5	8	4	4			11	29	2	13	14		14	8	3.6
33	27												37	40	15	25												4	117	2	4	5	2	7	4	29.25
34[1]	28													5	26		8												39	3	4	6			3	13.0
35	28													35	22	30	30	33	4									7	154	2	6	7	2	9	6	25.66
36	28													10	2	34												5	46	2	3	4	3	7	3	15.3
37	29														63	25	19	36	11	2								9	156	2	6	7	3	10	6	26.0

38	29																1		3	5	3	10	4	13	14	13	53	6	9	14	14	8	6.6
39	29														32	37	1	40	22	18						7	150	2	6	7	1	8	6	25.0
40	30															29	7	2	52							7	90	2	4	5	2	7	4	22.5
41	30															43	44	3	42							7	132	2	4	5	2	7	4	33.0
42	30															7	1	2		7	1					9	19	2	6	7	2	9	5	3.8
43	30																40	10	21	20	48	2				10	141	3	6	8	2	10	6	23.5
44	30																16	13	28	10						7	67	3	4	6	1	7	4	16.75
45	30															31	13	3	2							7	49	2	4	5	2	7	4	12.25
46	30															63										5	63	2	1	2	3	5	1	63.0
47	30																		27	45	44					9	116	5	3	7	2	9	3	38.66
48	July 6																					1	9	1		2	1	14	14	2	6	7	1	8	5	2.8
Total		8	88	182	60	71	69	414	199	258	295	251	168	212	220	408	215	231	227	172	115	13	20	16	8	15	15		3,950						

[1] Moth escaped before record was completed.

SUMMARY.

	Average.	Maximum.	Minimum.
Number of days from emergence of moth to first oviposition	3.02	6	2
Number of eggs deposited by each female	80.2	200	6
Number of eggs deposited per day per female	19.805	96	1
Length of oviposition period in days	5.7	13	1
Number of days of actual oviposition	5.02	9	1
Number of days from emergence of moth to last oviposition	7.7	15	2
Number of days moth lived after last oviposition	2.47	10	1
Length of life of moth in days	10.3	17	5

SUMMARY OF RECORDS.

A condensed summary of the records on the stages of the first generation is found in Table XLII. The average of the averages of the different stages is found to be 47.37 days, as compared with 46.91 days in the total life cycle column, a difference of but .46 day. The length of the life cycle of the insect of the first generation of 1912, as obtained by addition of the separate stages, was shown to be 50.62 days. This number is 3.25 days greater than the corresponding sum of the length of the several stages of the first generation during 1913.

TABLE XLII.—*Summary of records on the time of development of the codling moth of the first generation in its stages of egg, larva, and pupa, Roswell, N. Mex., 1918.*

Date of egg deposition.	Number of individuals.	Days of incubation.	Number of individuals.	Length of feeding larva.			Number of individuals.	Length of cocooning period.			Number of individuals.	Length of pupal stage.			Number of individuals.	Total length of life cycle.		
				Average days.	Minimum days.	Maximum days.		Average days.	Minimum days.	Maximum days.		Average days.	Minimum days.	Maximum days.		Average days.	Minimum days.	Maximum days.
Apr. 16	4	11	4	32.2	29	38	4	9.0	6	12	2	15.0	14	16	2	65.0	65	65
19	1	10	1	28.0	28	28												
28	2	7	2	23.5	23	24	1	5.0	5	5								
29	12	7	12	24.9	21	28	12	4.6	4	6	12	14.0	11	15	12	50.6	55	44
May 1	12	8	12	23.1	20	27	10	4.1	3	6	8	14.3	13	15	8	48.5	51	46
2	2	8	2	22.0	20	24	2	3.0	2	4	2	15.0	15	15	3	49.6	53	45
3	9	7	9	23.5	20	26	9	4.8	3	6	6	14.0	13	15	5	49.4	53	45
5	1	6	1	26.0	26	26	1	7.0	7	7								
7	3	6	3	20.7	19	26	3	3.6	3	4	2	14.5	14	15	3	45.3	47	43
8	7	6	7	21.8	19	24	7	6.2	3	11	6	14.1	11	21	6	48.0	51	43
9	3	6	3	22.7	22	24	2	5.0	4	6	2	14.0	14	14	2	48.0	48	48
10	5	5	5	23.8	22	28	5	5.8	4	7	3	12.0	11	13	3	47.7	49	47
11	6	5	6	26.1	21	31	4	6.0	5	7	2	13.0	13	13	2	48.0	51	45
12	7	5	7	27.8	25	31	6	12.0	9	15	6	7.8	5	15	6	54.1	60	51
13	16	5	16	25.1	19	29	14	9.9	5	21	5	15.2	10	19	5	51.2	54	47
14	8	5	8	26.5	24	31	8	7.0	4	11	8	12.1	10	19	8	50.6	56	46
19	8	5	8	27.2	25	32	8	5.3	2	8	6	9.3	8	11	6	47.0	50	45
21	7	6	7	25.3	22	29	7	5.0	4	6	4	10.5	10	11	4	48.0	46	51
23	2	4	2	25.2	23	28	1	4.0	4	4	1	11.0	11	11	1	47.0	47	47
24	7	4	7	24.0	22	27	3	5.3	5	6	2	8.0	7	9	2	39.5	39	40
25	10	4	10	24.3	21	27	8	6.9	3	14	6	10.3	9	11	6	45.3	43	50
26	12	5	12	24.0	21	28	13	4.1	3	5	12	10.9	8	16	12	43.9	40	48
27	7	5	7	22.2	19	24	7	3.8	2	5	5	11.4	9	16	5	41.4	39	44
28	20	5	20	24.4	21	26	19	5.1	4	15	16	10.4	9	12	16	44.3	43	47
29	15	6	15	23.4	20	27	15	4.4	3	6	14	10.6	8	14	14	44.2	40	48
30	13	5	13	23.0	19	27	11	4.1	4	5	10	11.4	9	16	10	43.0	40	47
31	13	5	13	23.5	16	29	13	5.5	4	8	8	10.6	10	12	8	44.6	40	50
	212	.....	212	24.45	.....	.....	193	5.7	.....	.....	148	11.76	.....	.....	149	46.91	.....	.....

Total days incubation for all eggs, 1,178; average incubation period, 5.5.

THE SECOND GENERATION.

THE SECOND BROOD OF EGGS.

Length of incubation.—Egg deposition of the second brood was found to cover a period of practically one month, extending from June 11 to July 12, and only a slight variation in the length of the several incubation observations is noted. It may be found by comparison that this period is practically 14 days shorter than the corresponding period for the first generation. In Table XLIII are included the records for 505 observations. The length of incubation varied here from 4 to 7 days. An average of 4.9 days is described for the entire period.

TABLE XLIII.—*Time of incubation of eggs and length of feeding period of larva, second brood, Roswell, N. Mex., 1913.*

Date of egg deposition.	Number of individuals.	Days of incubation.	Length of feeding period of larva in specified days.																	Average days.	Minimum days.	Maximum days.	Total days.
			14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	34				
June 11	12	6	....	....	....	3	2	1	1	2	2	....	1	....	....	....	....	....	....	....	19.8	17	24	238
12	2	7	....	....	....	1	1	....	....	....	....	....	....	....	....	....	....	....	....	....	17.5	17	18	35
13	9	6	....	....	1	2	2	2	1	....	....	....	1	....	....	....	....	....	....	....	18.7	16	24	168
14	25	6	....	1	....	2	3	9	5	4	....	....	....	....	1	....	....	....	....	....	19.4	15	26	484
15	14	5	....	....	1	....	1	4	2	4	....	....	2	....	....	....	....	....	....	....	20.1	16	24	282
16	20	5	....	1	2	1	3	1	4	3	2	....	1	....	2	....	....	....	....	....	20.0	15	26	400
17	40	5	....	....	2	4	4	5	8	7	3	3	1	3	....	....	....	....	....	....	20.2	16	25	808
18	29	6	....	....	....	6	5	4	8	....	4	1	1	....	....	....	....	....	....	....	19.4	17	24	563
19	33	5	....	3	5	8	7	5	2	2	2	....	....	....	....	....	....	....	1	....	17.6	15	30	582
20	19	5	....	....	....	2	....	2	6	1	1	1	1	....	2	1	1	....	1	....	22.0	17	30	419
21	25	5	....	....	....	....	3	4	2	7	3	2	....	3	1	....	....	....	....	....	21.2	18	26	530
22	50	5	....	7	13	8	9	5	3	....	....	1	....	4	....	....	....	....	....	....	17.8	15	25	889
23	34	4	....	....	....	1	7	6	2	6	4	3	2	2	1	....	....	....	....	....	20.7	17	26	704
24	31	4	....	2	4	6	1	3	3	1	2	5	2	2	....	....	....	....	....	....	19.6	15	25	609
25	12	5	....	....	3	2	1	2	2	2	....	....	....	....	....	....	....	....	....	....	18.3	16	21	220
26	20	5	....	....	....	3	5	1	3	3	1	2	....	1	....	....	....	1	....	....	20.3	17	29	405
27	33	5	....	....	4	4	5	1	5	2	3	4	1	....	....	2	1	....	1	....	20.5	16	30	677
28	25	5	....	....	3	3	4	2	1	4	1	1	1	1	1	1	....	2	....	....	20.7	16	29	518
29	25	5	....	3	1	2	1	3	6	4	1	1	....	1	1	....	1	....	....	....	19.9	15	28	498
30	16	4	....	1	3	2	3	4	....	....	2	1	....	....	....	....	....	....	....	....	18.3	15	23	294
July 1	9	5	....	2	2	1	1	....	....	....	....	2	....	....	....	1	....	....	....	1	22.6	15	34	204
3	5	5	....	....	....	1	....	1	....	1	....	....	....	....	....	....	1	....	....	....	21.7	17	28	87
6	4	5	....	....	....	....	....	1	1	....	....	1	1	....	....	....	....	....	....	....	21.5	19	24	86
7	4	5	....	1	....	....	....	....	1	....	1	....	....	....	....	....	1	....	....	....	21.2	15	28	85
9	8	5	....	....	1	1	....	2	....	1	....	2	1	....	....	....	....	....	....	....	20.2	16	24	162
12	2	4	1	....	....	....	1	....	....	....	....	....	....	....	....	....	....	....	....	....	16.0	14	18	32
	505	.....	1	21	45	63	69	67	67	53	33	30	16	17	9	5	5	3	3	1	19.7	.....	.....	9,979

Total days incubation for all eggs, 2,521; average incubation period, 4.9 days.

THE SECOND BROOD OF LARVÆ.

Length of feeding period.—The feeding period of second-brood larvæ is somewhat shorter than has been recorded for the first-brood larvæ, and is mainly the result of warmer and more settled weather conditions than were prevalent at the time the first-brood larvæ were feeding within the fruit. A more advanced stage of the fruit at this later period of the season was also probably conducive to a shorter feeding period. Of the 505 larvæ of the second brood under observation, one individual insect completed the feeding period in 14 days, the shortest time recorded, while the longest time was 34 days, thus making a range of variation of 20 days. An average of 19.7 days is computed on the whole number under observation, including both wintering larvæ and those transforming the same season. These records will be found in Table XLIII. The average length of the feeding period of larvæ of the first brood was 24.45 days, thus making an average of 4.75 days greater than larvæ of the second brood. Records on the corresponding period obtained during the season of 1912 show an average of 21.23 days:

Feeding period of wintering larvæ.—During the period of observations conducted with individuals of the second brood a total of 505 larvæ was used, and of this number 100 larvæ, or 19.98 per cent, proved to be wintering larvæ. In Table XLIV it is shown that a maximum of 34 days is found to exist for the feeding period and a minimum of 15 days, covering a range of variation of 19 days, with an average feeding period of 21.13 days. This period is 1.43 days greater than the average time for the transforming larvæ of the same brood, and is found to be practically identical with the corresponding period of the second generation during the preceding season.

TABLE XLIV.—*Length of feeding period of wintering larvæ of the second brood of the codling moth, Roswell, N. Mex., 1913.*

Date of egg hatching.	Number of individuals.	Length of feeding in specified days, being the time from hatching of egg to the leaving of fruit by larvæ.																Average days.	Minimum days.	Maximum days.	Total.
		15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	34				
June 22	5							3	1			1							22.0	21	25	110
24	8			3	1	2			2										18.8	17	22	151
25	2							1									1		25.5	21	30	51
26	2						1	1											20.5	20	21	41
27	18	1	2		5	1	2	1	1	1		4							20.0	15	25	362
28	5			1						2	1	1							22.4	17	25	112
30	7			1	1	2	1	2											19.2	17	21	135
July 1	7			1	1		2	2	1										19.8	17	22	139
2	10		1		2		1	2	1	1					1		1		21.7	16	30	217
3	13			1	2	1	1	2	1	1		1		1		2			22.2	17	29	289
4	12			1	1	1	2	2	2	2			1						21.0	17	26	252
6	4	1								1				1				1	24.7	15	34	99
8	3						1		1						1				22.3	20	28	70
11	1					1													19.0	19	19	19
12	2								1						1				25.0	22	28	50
14	1		1																16.0	16	16	16
	100	2	4	8	13	8	11	16	11	8	1	7	1	2	3	2	2	1	21.13			2,113

Larval life in the cocoon.—A comparison of the length of the cocooning period of the second generation with the corresponding period of the first generation shows practically no difference, and a fairly constant length of the period may be derived from the figures. Table XLV records the observations with 400 individuals, and while a maximum period is represented by 24 days and a minimum time by 2 days, giving a range of variation of 22 days, the results maintain an average period of only 5.6 days for all larvæ observed. This period is 0.44 day greater than the length of the cocooning period as observed with larvæ of the same generation during the season of 1912.

TABLE XLV.—*The making of cocoons of the second generation of the codling moth, Roswell, N. Mex., 1913.*

Date of egg deposition.	Number of individuals.	Length of cocooning period in specified days, being the time from leaving the fruit to the time of pupation.														Average days.	Minimum days.	Maximum days.	Total days.
		2	3	4	5	6	7	8	9	10	11	12	13	14	17	24			
June 11	12		1	3	6	2											4.8	3	6	57
12	2			2													2.0	4	4	8
13	9			3	5				1								5.1	4	9	46
14	25		3	20	1	1											4.0	3	6	100
15	14			6	2	2	1		2	1							5.7	4	10	81
16	18		1	9	4	1	1					1	1				5.4	3	13	97
17	33			12	8	4	3	2	1	1		2					5.8	4	12	192
18	23			4	10	2	5			1				1			5.9	4	14	137
19	31		5	13	10	2							1				4.6	3	13	142
20	17		1	5	2	5	2	1	1								5.5	3	9	94
21	23		1	3	8	6	3	2									5.6	3	8	128
22	38	2	1	4	13	4	3	2	3	2	3	1					6.3	2	12	241
23	26			2	8	10	3	2		1							6.9	4	10	155
24	26			8	3	4	5	3	2	1							6.0	4	10	158
25	5				2	2		1									6.0	5	8	30
26	13		1	2	4	3	1				1				1		6.5	3	17	84
27	23		4	2	8	7	1	1									5.0	3	8	117
28	12			3	6	1	2										5.1	4	7	62
29	15				5	3		1	1			2	2			1	8.9	5	24	134
30	14		1	6	4	1		1		1							5.1	3	10	71
July 1	6			2	2	1	1										5.1	4	7	31
3	1				1												5.0	5	5	5
6	3				2			1									6.0	5	8	18
7	2			1							1						7.5	4	11	15
9	9	1		1	1	1	1	2		1	1						6.7	2	11	61
	400	3	19	111	115	62	32	19	11	9	6	6	4	1	1	1	5.6			2,264

SECOND BROOD OF PUPÆ.

Length of pupal stage.—The length of the pupal stage of the second generation as compared with that of the first generation is found to differ very little. Of the 400 insects under observation 1 emerged 7 days after pupation had taken place, while the greater length of time was found to be 20 days. An average period of 11.6 days is shown for the entire number observed. Further reference should be made to Table XLVI.

TABLE XLVI.—*Length of pupal stage of the codling moth in days of all individuals developing from eggs deposited on specified dates, second brood, Roswell, N. Mex., 1913.*

Date of egg deposition.	Number of individuals.	Length of pupal stage in days.														Average days.	Minimum days.	Maximum days.	Total days.
		7	8	9	10	11	12	13	14	15	16	17	18	19	20				
June 11	12	...	...	...	5	5	2	...	...	...	...	...	...	...	...	10.8	10	12	129
12	2	...	...	1	1	...	...	...	...	...	...	...	...	...	...	9.5	9	10	19
13	13	...	...	...	...	5	3	1	...	...	...	...	...	...	...	11.5	11	13	104
14	25	1	...	2	5	5	8	4	...	...	...	...	...	...	...	11.1	7	13	278
15	14	...	...	1	1	5	4	2	...	1	...	...	...	...	...	11.6	9	15	163
16	18	...	...	2	1	4	6	2	...	1	2	...	...	...	...	12.0	9	16	217
17	33	...	1	...	5	6	13	3	...	3	...	...	1	1	...	12.2	8	19	401
18	23	...	...	...	1	1	15	4	1	...	1	...	...	...	...	12.3	10	16	283
19	31	...	...	1	6	14	6	3	...	1	...	...	...	...	...	11.2	9	15	349
20	17	...	...	1	...	10	3	2	1	...	...	...	...	...	...	11.5	9	14	195
21	23	...	...	...	4	10	6	1	2	...	...	...	...	...	...	11.4	10	14	263
22	38	...	...	2	3	16	7	3	3	3	...	1	...	...	...	11.6	9	17	451
23	26	...	...	...	6	10	7	2	1	...	...	...	...	...	...	11.3	10	14	294
24	26	...	...	...	4	17	4	...	...	...	1	...	...	...	...	11.1	10	16	291
25	5	...	...	...	2	2	...	...	...	...	...	1	...	...	...	11.8	10	17	59
26	13	...	...	4	3	5	...	...	...	1	...	...	...	...	...	10.4	9	15	136
27	23	...	...	1	8	11	1	...	...	...	...	1	...	...	1	11.2	9	20	259
28	12	...	...	1	4	5	...	...	...	...	...	2	...	...	...	11.5	9	17	138
29	15	...	...	1	6	4	2	...	...	1	...	...	1	...	...	11.4	9	19	171
30	14	...	...	1	4	5	4	...	...	...	...	...	...	...	...	10.8	9	12	152
July 1	6	...	...	1	2	2	...	...	1	...	...	...	...	...	...	10.8	9	14	65
3	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	9.0	9	9	9
6	3	...	...	...	3	...	...	...	...	...	...	...	...	...	...	10.0	10	10	30
7	2	...	...	...	1	...	1	...	...	...	...	...	...	...	...	11.0	10	12	22
9	7	...	1	3	2	1	...	...	...	...	...	...	...	...	...	9.4	8	11	66
12	2	...	...	...	1	...	1	...	...	...	...	...	...	...	...	11.0	10	12	22
	400	1	2	23	78	143	93	27	9	11	4	5	1	2	1	11.6	.....	.....	4,566

LENGTH OF LIFE CYCLE.

The length of time elapsing from the date of egg deposition to emergence of moth of the same generation for 407 individual insects is shown in Table XLVII. Of this number one insect completed the life cycle in 28 days, while the longest time recorded was 59 days. An average period of 41.4 days is described for the entire number observed, being 5.5 days shorter than the corresponding period of the first generation, and 0.14 day greater than the length of life cycle of the second generation of the insect as observed during the season of 1912.

TABLE XLVII.—*Length of life cycle of second generation of codling moth from time of egg deposition to emergence of moth, Roswell, N. Mex., 1913.*

Date of egg deposition.	Number of individuals.	Moths emerged in specified days from time of deposition of eggs of the same generation.																							Average days.	Minimum days.	Maximum days.	Total days.
		28	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	54	59					
June 11	13							2	3	2		1	3	1		1									41.07	38	46	534
12	2							2																	38.0	38	38	76
13	9						1		1	2	2			1		1	1								41.3	37	46	372
14	26				1	2	1	2	3	3	5	3	2	2	1				1						40.6	35	49	1,056
15	14				1				3	1	1	1		3		2		1	1						42.6	35	49	596
16	19		1	1			1		1	1	3	3	2		1	1	1	1		1	1				42.4	33	51	805
17	34				1		2	1	1	1	6	4	4	3		3	4	2	1	1					43.1	35	50	1,465
18	24								1	3	3	1	3	4	5	2				1		1			43.8	39	54	1,050
19	32			1	4	5	3	3	2	6	5	1		1					1						38.7	34	49	1,237
20	17								2	2		3	1	4		1	1	1	2						43.6	39	49	742
21	23								1	2	2	6	1	6			5								43.3	39	47	995
22	38				1	3	1	2	3	4	12	6	3		2	1									40.6	35	46	1,542
23	26							1	5	3	3	4	1	4	4	1									41.9	38	46	1,089
24	26				3			3	2	5	5	2	3	1	2										40.3	35	45	1,049
25	5					1	1			1		1		1											39.8	36	44	199
26	13						2		3		1		2	1	1		1	1	1						42.3	37	49	551
27	23	1					3	2	4	2	1	2	2	4		1	1								40.4	28	47	931
28	12						1	3	1	2			4				1								40.8	37	47	489
29	15						2			2	1		2	1	1	1		3	1				1		47.8	37	59	668
30	14			1	1	2	6		1	1		1		1											37.7	34	44	528
July 1	6					1	3	1								1									38.5	36	46	231
3	2		1			1																			34.5	33	36	69
6	3													2	1										43.3	43	44	130
7	2			1														1							41.0	34	48	82
9	7								2	1			2		1	1									42.1	39	46	295
12	2		1									1													37.5	33	42	75
	407	1	3	4	12	15	27	22	39	44	50	40	38	38	19	17	14	10	8	3	1	1	1		41.4			16,856

SECOND BROOD OF MOTHS.

Egg deposition.—A total of 38 individual female moths of the second brood emerging in the interval between July 14 and August 17 were isolated in order to obtain oviposition records as shown by moths in confinement. Reference to Table XLVIII will show that a total of 4,847 eggs were deposited by the 38 females, an average oviposition of 127.55 per individual. The maximum individual oviposition was 259 eggs. The average individual oviposition per day was 16.6 eggs, and the maximum daily oviposition per female was 108 eggs. On an average the length of the oviposition period was 8.3 days, although the maximum length of the period was 16 days. It was also found that actual oviposition by an individual female may occur on 14 separate days, but the average number found in this connection is 7.6 days. The observations showed that it was possible for oviposition to begin as early as one day following emergence, although the average length of time was 3.68 days. The longevity of the moths thus confined varied considerably, one insect living but 6 days, while another individual persisted for 21 days after emergence. The average length of life of the moths in this connection was 12.8 days.

TABLE XLVIII.—*Egg deposition by individual codling moths of the second brood, Roswell, N. Mex., 1913.*

| Moth No. | Date of emergence of moths. | Date of oviposition and number of eggs deposited. | | |

TABLE XLVIII.—*Egg deposition by individual codling moths of the second brood, Roswell, N. Mex., 1913.* Continued.

Moth No.	Date of emergence of moths.	Death of moth.	Total number of eggs per moth.	Length of period before first oviposition.	Period from first to last oviposition.	Period from emergence to last oviposition.	Life of moth after last oviposition.	Total length of life of moth.	Number of days on which oviposition [1] occurred.	Average number of eggs per oviposition per female.
				Days.	*Days.*	*Days.*	*Days.*	*Days.*		
1	July 14	July 27	104	4	8	11	2	13	8	13.0
2	16	28	239	2	10	11	1	12	10	23.9
3	16	25	178	2	6	7	2	9	6	29.6
4	16	27	58	5	5	9	2	11	5	11.6
5	18	Aug. 6	74	4	14	17	2	19	14	5.2
6	18	July 24	62	3	3	5	1	6	3	20.6
7	20	Aug. 3	177	6	8	13	1	14	8	22.1
8	20	3	114	5	7	11	3	14	6	19.0
9	20	6	78	5	11	15	2	17	10	7.8
10	21	1	237	1	5	5	3	8	5	47.4
11	21	6	130	5	7	11	2	13	6	21.7
12	21	4	105	4	6	9	2	11	6	16.6
13	21	9	121	5	10	14	2	16	9	13.3
14	24	8	259	1	9	9	5	13	9	28.7
15	25	8	62	3	7	9	2	11	7	8.8
16	25	.....	130	1	3	3	.....	.....	3	43.3
17	25	.....	116	1	2	2	.....	.....	2	58.0
18	25	12	85	1	9	9	6	15	7	12.1
19	28	5	100	1	7	7	1	8	5	20.0
20	30	10	236	1	9	9	2	11	8	29.5
21	30	6	101	2	3	4	3	7	3	33.6
22	Aug. 2	16	55	6	7	12	2	14	6	9.2
23	2	8	187	1	4	4	2	6	4	46.7
24	8	23	114	5	9	13	2	15	7	16.3
25	9	26	164	3	10	12	5	17	10	16.4
26	9	30	114	5	16	20	1	21	14	8.2
27	9	27	79	9	8	16	2	18	8	9.9
28	10	21	63	2	6	7	4	11	6	10.5
29	10	31	156	4	16	9	2	21	14	11.1
30	10	27	120	5	11	10	2	17	10	12.0
31	13	30	160	2	12	13	4	17	9	17.7
32	13	Sept. 1	109	3	14	16	3	19	11	9.9
33	13	Aug. 23	79	3	6	8	2	10	6	13.2
34	13	30	125	4	13	16	1	17	13	9.5
35	15	29	58	4	10	13	1	14	9	6.4
36	15	28	218	2	10	11	2	13	10	21.8
37	15	29	89	7	7	13	1	14	6	14.8
38	17	30	191	3	9	11	2	13	8	23.8
Total	.....	.....	4,847	.....	.....	.....	.....	.....	.....	.....

[1] Moth escaped before record was completed.

	Average.	Maximum.	Minimum.
Number of days from emergence of moth to first oviposition	3.68	9	1
Number of eggs deposited by each female	127.55	259	55
Number of eggs deposited per day per female	16.6	108	1
Length of oviposition period in days	8.3	16	2
Number of days of actual oviposition	7.6	14	2
Number of days from emergence of moth to last oviposition	10.6	20	2
Number of days moth lived after last oviposition	2.15	6	1
Length of life of moth in days	12.8	21	6

SUMMARY OF RECORDS FOR SECOND GENERATION.

In Table XLIX there appears a summary of the records on the time development of the codling moth of the second generation in the stages of egg, larva, and pupa. The sum of the average periods spent in the several stages totals 41.8 days as compared with 41.4 days given as the average length of the life cycle of the second generation. These figures compare very closely with corresponding data obtained during 1912.

TABLE XLIX.—*Summary of records on the time of development of the codling moth, second generation, in the stages of egg, larva, and pupa, Roswell, N. Mex., 1913.*

Date of egg deposition.	Number of individuals.	Days of incubation.	Number of individuals.	Length of feeding larva.			Number of individuals.	Length of cocooning period.			Number of individuals.	Length of pupal stage.			Number of individuals.	Total length of life cycle.		
				Average days.	Minimum days.	Maximum days.		Average days.	Minimum days.	Maximum days.		Average days.	Minimum days.	Maximum days.		Average days.	Minimum days.	Maximum days.
June 11	13	6	12	19.8	17	24	12	4.8	3	6	12	10.8	10	12	13	41.07	38	46
12	2	7	2	17.5	17	18	2	2.0	4	4	2	9.5	9	10	2	38.0	38	38
13	9	6	9	18.7	16	24	9	5.1	4	9	9	11.5	11	13	9	41.3	37	46
14	26	6	25	19.4	15	26	25	4.0	3	6	25	11.1	7	13	26	40.6	35	49
15	14	5	14	20.1	16	24	14	5.7	4	10	14	11.6	9	15	14	42.6	35	49
16	20	5	20	20.0	15	26	18	5.4	3	13	18	12.0	9	16	19	42.4	33	51
17	10	5	10	20.2	16	25	33	5.8	4	12	33	12.2	8	19	34	43.1	35	50
18	29	6	29	19.4	17	24	23	5.9	4	14	23	12.3	10	16	24	43.8	39	54
19	33	5	33	17.6	15	30	31	4.6	3	13	31	11.2	9	15	32	38.7	34	49
20	19	5	19	22.0	17	30	17	5.5	3	9	17	11.5	9	14	17	43.6	39	49
21	25	5	25	21.2	18	26	23	5.6	3	8	23	11.4	10	14	23	43.3	39	47
22	50	5	50	17.8	15	25	38	6.3	2	12	38	11.6	9	17	38	40.6	35	46
23	34	4	34	20.7	17	26	26	6.9	4	10	26	11.3	10	14	26	41.9	38	46
24	31	4	31	19.6	15	25	26	6.0	4	10	26	11.4	10	16	26	40.3	35	45
25	12	5	12	18.3	16	21	5	6.0	5	8	5	11.8	10	17	5	39.8	36	44
26	20	5	20	20.3	17	29	13	6.5	3	17	13	10.4	9	15	13	42.3	37	49
27	33	5	33	20.5	16	30	23	5.0	3	8	23	11.2	9	20	23	40.4	28	47
28	25	5	25	20.7	16	29	12	5.1	4	7	12	11.5	9	17	12	40.8	37	47
29	25	5	25	19.9	15	28	15	8.9	5	24	15	11.4	9	19	15	47.8	37	59
30	16	4	16	18.3	15	23	14	5.1	3	10	14	10.8	9	12	14	37.7	34	44
July 1	9	5	9	22.6	15	34	6	5.1	4	7	6	10.8	9	14	6	38.5	36	46
3	4	5	4	21.7	17	28	1	5.0	5	5	1	9.0	9	9	2	34.5	33	36
6	4	5	4	21.5	19	24	3	6.0	5	8	3	10.0	10	10	3	43.3	43	44
7	4	5	4	21.2	15	28	2	7.5	4	11	2	11.0	10	12	2	41.0	34	48
9	8	5	8	20.2	16	24	9	6.7	2	11	7	9.4	8	11	7	42.1	39	46
12	2	4	2	16.0	14	18	.....	.....	.....	.....	2	11.0	10	12	2	37.5	33	42
	507		505	19.7			400	5.6			400	11.6			407	41.4		

Total days incubation for all eggs, 2,533; average incubation period, 4.9.

THE THIRD GENERATION.

THIRD BROOD OF EGGS.

Time of incubation.—Eggs of the third brood were found in the field July 10, and deposition continued more or less regularly until August 11, a period of slightly more than one month The length of this period of deposition is found by comparison to be practically identical with that of the second brood, but is exceeded by the corresponding period of the first brood by 13 days. Of 180 observations made, an average incubation period of 5.3 days is found. These records appear in Table L. In comparing this period with average incubation periods of the previous broods, it will be noted that the first brood experienced a somewhat longer incubation period, it being 5.96 days, while that of the second brood was somewhat shorter, 4.9 days.

TABLE L.—*Time of incubation of eggs of the codling moth and length of feeding period of third brood larvæ, Roswell, N. Mex., 1913.*

Date of egg deposition.	Number of individuals.	Days of incubation.	Length of feeding period of larva in specified days.														Average days.	Minimum days.	Maximum days.	Total days.
			15	16	17	18	19	20	21	22	23	24	25	26	27	28				
July 10	12	5	.....	1	1	6	.....	2	.....	1	.....	.....	1	.....	.....	.....	19.0	16	25	228
13	1	6	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	20.0	20	20	20
14	14	5	.....	.....	1	.....	3	1	4	3	.....	.....	.....	.....	2	.....	21.2	17	27	298
15	19	5	.....	.....	1	2	3	6	1	3	.....	1	1	.....	1	.....	20.6	17	27	393
16	7	5	.....	.....	.....	1	1	2	1	2	.....	.....	.....	.....	.....	.....	20.2	18	22	142
17	11	6	.....	.....	1	4	1	2	3	.....	.....	.....	.....	.....	.....	.....	19.1	17	21	211
18	15	7	.....	3	1	3	2	1	.....	1	.....	.....	1	.....	1	2	20.4	16	28	307
19	2	6	.....	.....	.....	.....	1	1	.....	.....	.....	.....	.....	.....	.....	.....	19.5	19	20	39
20	9	6	2	.....	.....	.....	1	1	.....	1	2	1	.....	1	.....	.....	20.7	15	26	187
21	12	6	1	.....	.....	4	2	.....	.....	1	2	1	.....	.....	1	.....	20.3	15	27	244
22	1	5	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	19.0	19	19	19
23	8	5	.....	.....	.....	2	2	3	.....	1	.....	.....	.....	.....	.....	.....	19.5	18	22	156
24	16	5	.....	.....	1	.....	1	2	2	6	.....	2	1	.....	1	.....	21.9	17	27	350
25	8	5	.....	1	.....	1	2	.....	.....	3	1	.....	.....	.....	.....	.....	20.1	16	23	161
26	5	5	.....	.....	.....	1	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	18.8	18	19	94
27	2	6	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	18.0	18	18	36
28	4	5	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	1	.....	1	.....	22.0	18	27	88
29	7	5	.....	2	.....	.....	1	1	.....	1	1	1	.....	.....	.....	.....	20.0	16	24	140
30	6	5	.....	1	.....	.....	2	2	1	.....	.....	.....	.....	.....	.....	.....	19.1	16	21	115
31	4	5	.....	.....	1	1	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	18.7	17	20	75
Aug. 1	5	5	.....	.....	2	2	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	18.0	17	20	90
3	2	6	.....	.....	1	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	20.0	17	23	40
5	1	5	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	19.0	19	19	19
6	7	5	.....	3	1	.....	2	.....	1	.....	.....	.....	.....	.....	.....	.....	17.7	16	21	124
11	2	5	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	17.0	17	17	34
	180	.....	3	11	13	31	30	28	13	23	7	6	5	1	7	2	20.0	.....	.....	3,610

Total days incubation for all eggs, 969; average incubation period, 5.3 days.

THIRD BROOD OF LARVÆ.

Length of feeding period.—In Table L are also found the records on the length of the feeding period of transforming larvæ of this generation. Of the 180 individual insects under observation in this connection the results show that 31 of the number completed the stage within 18 days. The maximum number of feeding days is 28, the minimum number 15, and the average is 20 days for the whole series. This average is found to be somewhat greater than the corresponding average for the second brood, but is 4.45 days shorter than the same time for the first brood.

Feeding period of wintering larvæ.—Of the 722 larvæ of the third brood under observation in this connection, 542 or 75.06 per cent, were found to be wintering larvæ. The maximum length of the feeding period of the wintering larvæ was 35 days, as contrasted with the maximum of 28 days, which is the longest corresponding period for transforming larvæ of the same brood. The shortest feeding period recorded is 14 days, while an average of 21.1 days exceeds the average period for the transforming larvæ by only 1.1 days. See Table LI.

TABLE LI.—*Length of feeding period of wintering codling-moth larvæ of the third brood, Roswell, N. Mex., 1913.*

Date of hatching of eggs.	Number of individuals.	Length of feeding in specified days, being the time from hatching of eggs to the leaving of fruit by larvæ.																					Average days.	Maximum days.	Minimum days.	Total days.
		14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35				
July 15	29				3	4	6	1	7	1		5	2											20.6	25	17	596
16	8							1	3	1	1		1						1					23.0	31	20	184
18	9					2	1	2	1	2		1												20.4	24	18	184
19	15				1	2	6	2	1	1	1													20.0	27	17	300
20	34				2	3	4	11	6	1	2	1	2	1		1								20.8	28	17	706
21	19				2	2	2	2	5			1		1	1		2					1		22.2	34	17	422
23	10				2			3		1						2		1					1	23.7	35	17	237
24	19			1	1	1	2	5		3				4			2							21.9	29	16	417
25	7								1	1		1	1	2	1									24.4	27	21	171
26	16		1			2	1	2	1		5		2		1	1								21.9	28	15	351
27	13		1		1		4		1		1	2	2		1									21.3	27	15	277
28	22							6	5	1	1	2	1		1	5								23.2	28	20	510
29	24				1		3	4	1	3	1	2	1	2	1	2		1				2		23.7	33	17	568
30	38		1	1	1	7	16	1	1	3	3	3								1				19.9	32	15	758
31	43		1	1	1	7	4	3	3	4	6	5	3	1					1	2		1		22.0	34	15	946
Aug. 1	38			3	8	2	4	5	4	3	3	2			1	1	1	1						20.4	30	16	777
2	27				4	4	1	6	3	5		1	1		1	1								20.6	28	17	556
3	13			1		2	1	2		4	2	1												20.7	24	16	269
4	22					2	10	3	1	1	3		1			1								20.5	28	18	451
6	20			1	8	4		3	1		2	1												18.8	24	16	375
7	27		1	8	7	3	2		1	1	1		1		2									18.5	27	15	499
8	24			1	1	2	1		2	3	2	3	3		3	1	1	1						23.2	30	16	557
10	16				2		8		1	1			1	1		2								21.0	28	17	336
11	7		2	1	2		1		1															17.1	21	15	120
12	8		1					1	2	1	1		2											21.5	25	15	172
16	7					1	2	1	2		1													20.1	23	18	141
20	8							2	2	1		1	1	1										22.4	26	20	179
22	7		1				2					1	2	1										21.9	26	19	153
24	5				1	1	1			2														19.6	22	17	98
26	7		2	1					2	2														18.9	22	15	132
	542		11	19	48	51	82	66	58	46	36	33	27	14	14	17	6	5	3	1	2	2	1	21.1			11,442

Larval life in the cocoon.—Observations in this case were made with 180 individual insects to determine the length of the cocooning period. The longest single period was found to be 19 days, and the minimum period 2 days, while an average of 6.2 days prevailed. This is somewhat longer than the average of 5.7 days found for the corresponding period for the first brood and 5.6 days for the second generation. The results of these observations appear in Table LII.

TABLE LII.—*The making of cocoons of third-brood larvæ of the codling moth, Roswell, N. Mex., 1913.*

Date of egg deposition.	Number of individuals.	Length of cocooning period in specified days, being the time from leaving the fruit to the time of pupation.															Average days.	Minimum days.	Maximum days.	Total days.
		2	3	4	5	6	7	8	9	10	11	12	13	14	15	19				
July 10	12			3	5			3	1								5.8	4	9	70
13	1			1													4.0	4	4	4
14	14			3	2	1	4	1	1			1				1	7.4	4	19	104
15	19		1	2	3	5	5	1	1		1						6.3	3	11	119
16	7		1	3		2	1										4.8	3	7	34
17	11	1	1	2	4	3											4.6	2	6	51
18	15		3	4	6		1								1		5.1	3	15	77
19	2			1		1											5.0	4	6	10
20	9		2	3	1	1			1		1						5.4	3	11	49
21	12		2	2	5	3											4.7	3	6	57
22	1			1													4.0	4	4	4
23	8		1	5	1	1											4.2	3	6	34
24	16			1	5	3	2		1	1	1	2					7.1	4	12	115
25	8				1		3		2		1			1			8.6	5	14	69
26	5					3	1				1						7.2	6	11	36
27	2					1		1					1				7.0	6	8	14
28	4				1	1											7.7	5	13	31
29	7						3	1	1	1	1						8.4	7	11	59
30	6				1	1	1		2		1						7.8	5	11	47
31	4		1				1	1		1							7.0	3	10	28
Aug. 1	5			1	1	1		1	1								6.4	4	9	32
3	2	1					1										4.5	2	7	9
5	1							1									8.0	8	8	8
6	7	1			3	1	1	1									5.4	2	8	38
11	2							1	1								8.5	8	9	17
	180	3	12	32	39	28	25	12	12	3	7	3	1	1	1	1	6.2			1,116

THIRD BROOD OF PUPÆ.

Length of pupal stage.—The observations made on the length of the pupal stage of the third brood, as found in Table LIII, show that of the entire number of 180 individuals accounted for, 53 of that number completed the pupal period in 11 days. The maximum length of the stage is shown to be 17 days and the minimum time 7 days. The average is found to be 11.4 days and this is practically identical in length with that of the corresponding period of the preceding brood, 11.6 days, and is exceeded only slightly by the corresponding average for the first brood, namely, 11.76 days. The average pupal period for the spring brood, 22.97 days, is found to be almost twice as long as that of succeeding generations of the same season.

TABLE LIII.—*Length of pupal stage of the codling moth in days of all individuals developing from eggs deposited on specified dates, third brood, Roswell, N. Mex., 1913.*

Date of egg deposition.	Number of individuals.	Length of pupal stage in days.											Average days.	Minimum days.	Maximum days.	Total days.
		7	8	9	10	11	12	13	14	15	16	17				
July 10	12			2	7	2	1						10.1	9	12	122
13	1				1								10.0	10	10	10
14	14			1	2	8	2	1					11.0	9	13	154
15	19			3	8	7	1						10.3	9	12	196
16	7				1	5	1						11.0	10	12	77
17	11				1	7	2	1					11.2	10	13	124
18	15			2	2	6	2	3					11.1	9	13	167
19	2					2							11.0	11	11	22
20	9				3	1	3			1		1	12.1	10	17	109
21	12			2	4	2	2	1	1				10.9	9	14	131
22	1					1							11.0	11	11	11
23	8				1	3	4						11.3	10	12	91
24	16			2	3	3	5	2			1		11.4	9	16	183
25	8			1	1	1	3	1	1				11.6	9	14	93
26	5				1	1		2	1				12.2	10	14	61
27	2			1		1							10.0	9	11	20
28	4							3	1				13.2	13	14	53
29	7	1			1	1		1	1	1	1		12.2	7	16	86
30	6		1				2	1	1	1			12.3	8	15	74
31	4			1		1			2				12.0	9	14	48
Aug. 1	5					1	1		3				13.0	11	14	65
3	2							1		1			14.0	13	15	28
5	1							1					13.0	13	13	13
6	7				1			1		3	2		14.2	10	16	100
11	2						2						12.0	12	12	24
	180	1	1	15	37	53	31	19	11	7	4	1	11.4			2,062

LENGTH OF LIFE CYCLE.

A study of Table LIV will show that of 185 individual insects which completed the life cycle of the third generation, two passed through the several stages in 34 days, this being the shortest time recorded. Also that one insect required a maximum time of 58 days, and that an average of 43.11 days is found for the entire number. This period in comparison with the average length of life cycle of previous generations is shown to be 1.71 days greater than the corresponding period for the second brood and 3.8 days shorter than the same period for the first generation. The average period for the length of the life cycle for the third generation during 1912 was 48.57 days, a difference of 5.46 days.

TABLE LIV.—*Length of life cycle of third generation of codling moth from time of egg deposition to emergence of moth, Roswell, N. Mex., 1913.*

Date of egg deposition.	Number of individuals.	Moths emerged in specific days from time of deposition of eggs from same generation.																					Average days.	Minimum days.	Maximum days.	Total days.
		34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	53	55	57	58				
July 10	13			3	3			2	3		1															
13	1							1											1					39.7	36	51	516
14	14							2	2	1		4	1	1		1	1						1	40.0	40	40	40
15	22	1		1			1	3	2	1	3	4	2	1	3									44.7	40	58	626
16	7				1		1			3	2													42.5	34	47	935
17	11			1	1		1		3		3	2												41.1	37	43	288
18	15				3		1	2	1	1			1	1	1	1			1	2				41.0	36	44	452
19	2							1			1													43.7	37	53	656
20	9		2			1								1		1	1		1		1			41.5	40	43	83
21	13	1			1	1	2		1	1	2					1	1		2					44.3	35	55	399
22	1						1																	35.0	34	51	555
23	8				1	1		2	3		1													39.0	39	39	39
24	16						1	1		2		4	2			3	2					1		40.1	37	43	321
25	8									1	1	1	1	2	1			1						45.5	39	57	728
26	5								1		2	1	1											45.3	42	50	363
27	2						1				1													43.2	41	45	216
28	4										1													41.0	39	43	82
29	7								1	1	1			2			1	2						48.0	43	50	192
30	6									2	1		1		2				2					45.7	41	51	320
31	4					1	1								2									44.3	42	47	266
Aug. 1	5					1	1						3		2									42.7	38	47	171
3	2											1	1											42.4	38	45	212
5	1												1											44.5	44	45	89
6	7					1		1	1	1		2				1								45.0	45	45	45
11	2									1	1													42.4	38	48	297
	185	2	2	5	10	6	11	15	18	16	21	19	11	8	9	8	6	3	7	2	1	1	1	42.5	42	43	85
																								43.11			7,976

THIRD BROOD OF MOTHS.

Time of emergence.—Because of a slight overlapping of the periods of emergence of moths of the second and third broods transforming from larvæ collected from banded trees in orchards, the records showing the time of emergence of moths of the two broods are consolidated and appear in Table LV.

The data show the first emergence of moths of the second generation to have occurred July 6, and a maximum number of moths of this brood to have appeared on August 6, or practically one month later. Emergence continued quite irregularly until September 19, although moths of the third brood apparently reached a maximum of emergence on August 28. The variations in the periods of emergence of the two broods shown by means of curves appear in figure 10, and illustrate very concisely the features of the periods and the time of occurrence.

TABLE LV.—*Time of emergence of codling moths of the second and third broods, Roswell, N. Mex., 1913.*

Date of emergence.	Number of moths.	Date of emergence.	Number of moths.
July 6	1	Aug. 13	151
7	18	14	146
8	20	15	96
9	34	16	112
10	24	17	115
11	52	18	97
12	34	19	109
13	35	20	59
14	56	21	52
15	31	22	74
16	40	23	40
17	54	24	33
18	40	25	60
19	98	26	29
20	97	27	42
21	47	28	57
22	88	29	47
23	157	30	28
24	201	31	36
25	125	Sept. 1	47
26	260	2	28
27	331	3	19
28	420	4	22
29	297	5	15
30	431	6	19
31	457	7	20
Aug. 1	404	8	18
2	399	9	20
3	362	10	11
4	473	11	10
5	411	12	2
6	475	13	4
7	409	14	7
8	401	15	8
9	329	16	3
10	301	17	1
11	250	19	2
12	134		

SUMMARY OF RECORDS.

In Table LVI may be found a comparatively complete summary of records on the several stages of the life cycle of the codling moth of

the third generation, showing the average length of the periods of each stage. The sum of the averages of the stages is found to be

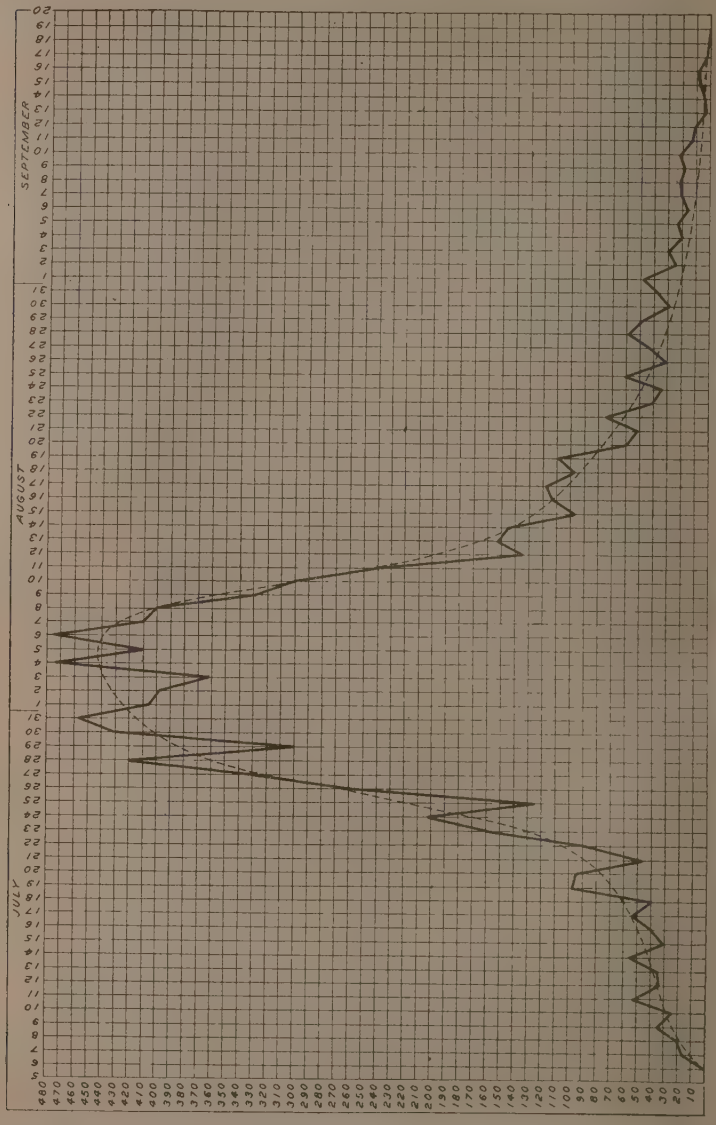

FIG. 10.—Curve showing emergence of codling moths of second and third broods, Roswell, N. Mex., 1913. (Original.)

42.9 days, while the average length of the total life cycle of this generation is 43.11 days, a difference of but 0.2 days.

TABLE LVI.—*Summary records on the time of development of the codling moth of the third generation in its stages of egg, larva, and pupa, Roswell, N. Mex., 1913.*

Date of egg deposition.	Number of individuals.	Days of incubation.	Number of individuals.	Length of feeding larva.			Number of individuals.	Length of cocooning period.			Number of individuals.	Length of pupal stage.			Number of individuals.	Total length of life cycle.		
				Average days.	Minimum days.	Maximum days.		Average days.	Minimum days.	Maximum days.		Average days.	Minimum days.	Maximum days.		Average days.	Minimum days.	Maximum days.
July 10	13	5	12	19.0	16	25	12	5.8	4	9	12	10.1	9	12	13	39.7	36	51
13	1	6	1	20.0	20	20	1	4.0	4	4	1	10.0	10	10	1	40.0	40	40
14	14	5	14	21.2	17	27	14	7.4	4	19	14	11.0	9	13	14	44.7	40	58
15	22	5	19	20.6	17	27	19	6.3	3	11	19	10.3	9	12	22	42.5	34	47
16	7	5	7	20.2	18	22	7	4.8	3	7	7	11.0	10	12	7	41.1	37	43
17	11	6	11	19.1	17	21	11	4.6	2	6	11	11.2	10	13	11	41.0	36	44
18	15	7	15	20.4	16	28	15	5.1	3	15	15	11.1	9	13	15	43.7	37	53
19	2	6	2	19.5	19	20	2	5.0	4	6	2	11.0	11	11	2	41.5	40	43
20	9	6	9	20.7	15	26	9	5.4	3	11	9	12.1	10	17	9	44.3	35	55
21	13	6	12	20.3	15	27	12	4.7	3	6	12	10.9	9	14	13	35.0	34	51
22	1	5	1	19.0	19	19	1	4.0	4	4	1	11.0	11	11	1	39.0	39	39
23	8	5	8	19.5	18	22	8	4.2	3	6	8	11.3	10	12	8	40.1	37	43
24	16	5	16	21.9	17	27	16	7.1	4	12	16	11.4	9	16	16	45.5	39	57
25	8	5	8	20.1	16	23	8	8.6	5	14	8	11.6	9	14	8	45.3	42	50
26	5	5	5	18.8	18	19	5	7.2	6	11	5	12.2	10	14	5	43.2	41	45
27	2	6	2	18.0	18	18	2	7.0	6	8	2	10.0	9	11	2	41.0	39	43
28	4	5	4	22.0	18	27	4	7.7	5	13	4	13.2	13	14	4	48.0	43	50
29	7	5	7	20.0	16	24	7	8.4	7	11	7	12.2	7	16	7	45.7	41	51
30	6	5	6	19.1	16	21	6	7.8	5	11	6	12.3	8	15	6	44.3	42	47
31	4	5	4	18.7	17	20	4	7.0	3	10	4	12.0	9	14	4	42.7	38	47
Aug. 1	5	5	5	18.0	17	20	5	6.4	4	9	5	13.0	11	14	5	42.4	38	45
3	2	6	2	20.0	17	23	2	4.5	2	7	2	14.0	13	15	2	44.5	44	45
5	1	5	1	19.0	19	19	1	8.0	8	8	1	13.0	13	13	1	45.0	45	45
6	7	5	7	17.7	16	21	7	5.4	2	8	7	13.8	10	16	7	42.4	38	48
11	2	5	2	17.0	17	17	2	8.5	8	9	2	12.0	12	12	2	42.5	42	43
	185	.....	180	20.0	.....	.....	180	6.2	.....	.....	180	11.4	.....	.....	185	43.11	.....	.....

Total days incubation for all eggs, 952; average incubation period, 5.3 days.

FOURTH BROOD OF EGGS.

Time of incubation.—Egg deposition for the fourth brood of the codling moth was first found to occur on August 20, and to continue more or less regularly until September 8, thus covering a period of 19 days. From the depositions occurring in this interval a total of 125 individuals was observed and found to have an average incubation period of 7.9 days. The maximum length of the period was 10 days, and the minimum time 5 days. These records are found in Table LVII.

TABLE LVII.—*Time of incubation and length of feeding period of larvæ of the fourth brood, Roswell, N. Mex., 1913.*

Date of egg deposition.	No. individuals.	Days incubation.	Length of feeding period in specified days.																								Average days.	Minimum days.	Maximum days.	Total.
			25	26	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	53				
Aug. 20	4	6			2								2																	32	28	36	128
21	6	6		4															2											31.3	26	42	188
22	3	6	2	1																										25.3	25	26	76
23	4	6	1	1													2													32.7	25	40	131
24	1	5											1																	36	36	36	36
25	1	6																						1						47	47	47	47
26	1	7																	1											42	42	42	42
27	7	8				1		1			3														1		1			44.3	30	51	266
28	10	8				2					1		4							3						1	1		1	38.7	29	53	387
29	6	7									2		1																	38.8	34	43	233
30	6	9						3		2			1																	32.5	31	36	195
31	11	9					4		2			1			2	2														33.7	30	39	371
Sept. 1	16	8										3		2	2	2	1		2	1			1		1	1				40.2	35	49	643
2	11	8												1	1	2	1		1	2	1		2							41.5	37	46	457
3	17	8												4			1	1	1		3	1	1	2			3			42.8	37	50	728
4	6	8														1	1							1		3				45.5	39	49	273
5	4	8														1		1	1						1					42.5	39	48	170
6	8	10								1		2	1	1		1				1		1								37.8	33	45	303
8	3	9										1							1		1									40.3	35	44	121
	125		3	6	2	2	5	3	3	3	3	10	10	8	5	9	6	2	9	7	5	2	4	4	3	5	4	1	1	38.36			4,795

Total days incubation for all eggs, 990; average incubation period, 7.9 days.

FOURTH BROOD OF LARVÆ.

Length of feeding.—The first observation of larvæ leaving the fruit was made September 23, after a feeding period of 28 days. Records in this connection were kept with 125 individual insects and the last larvæ were found leaving the fruit on October 31, thus covering a period of 28 days. All of these individuals passed the winter as wintering larvæ.

The maximum length of the feeding period for larvæ of this generation was found to be 53 days, and the minimum period 25 days, covering a range of variation of 28 days. The average feeding period for the entire time was 38.36 days, as shown in Table LVII. This average feeding period is 17.26 days greater than the corresponding average for wintering larvæ of the third generation of this season, and 11.81 days greater than the corresponding average for all larvæ of the third generation during 1912.

MISCELLANEOUS EMERGENCE OF MOTHS.

Records of hourly observations.—In an endeavor to determine the time of day at which the greatest number of insects leave the pupal case and emerge as moths, experiments were conducted by using a number of glass jars in which larvæ collected from banded trees had been placed and on which daily emergence records were taken. The first observations of the season were made April 28, using moths of the spring brood. Observations were begun at 7 a. m. and continued throughout the day at intervals of one hour until 7 p. m. Largely because of the cool weather prevailing at that early stage of the season no emergences were found to take place until 11 a. m., when 1 moth was discovered. At 12 noon, however, 35 moths were found and at this hour a thermograph within the breeding shelter indicated a temperature of 84° Fahrenheit. At 1 p. m. a total of 14 moths was found and a temperature of 85° F. was recorded and later noted as being the highest temperature throughout the day.

On June 24 and 25 similar experiments were again conducted although no observations were made until 9 a. m., when the greatest number of accumulated moths was found for any particular hour, being 55 in all. Records show an average temperature of 70° F., for that hour on the two days. However, the highest emergence during the more heated portion of the day occurred at 3 p. m. with a total of 33 moths and an average temperature of 90° F., for that hour on the two days.

On August 1 similar records were made with emerging moths of the second generation, and the first observation of the day was made at 7 a. m., when a total of 19 moths was found. The maximum emergence of the day, however, occurred at 3 p. m., when 103 individuals were discovered. The temperature records at this hour read 83° F., while the maximum temperature of the day occurred at 12 noon and was found to be 89° F. Emergences for other hours throughout the day on which records were taken were found to be in varying numbers, as is shown in Table LVIII. Of a total of 731 records of individual emergences,

137 occurred at 3 p. m. which, according to these records, can be considered the hour of maximum emergence.

TABLE LVIII.—*Records of hourly emergence of codling moths of the spring brood, and of the first and second broods, Roswell, N. Mex., 1913.*

Date of observation.	Hour of day.												Total emergence
	7 a. m.	8 a. m.	9 a. m.	10 a. m.	11 a. m.	12 m.	1 p. m.	2 p. m.	3 p. m.	4 p. m.	5 p. m.	6 p. m.	7 p. m.	
Spring brood:														
Apr. 28	.....	.....	.....	.....	1	35	14	4	1	3	1	.....	.....	59
First brood:														
June 24	.....	.....	7	.....	.....	.....	2	1	2	.....	.....	.....	.....	10
24	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
24	.....	.....	21	2	4	4	4	5	3	.....	.....	.....	.....	43
24	.....	.....	.....	31	6	10	8	13	17	5	7	3	2	102
24	.....	.....	.....	.....	.....	.....	.....	5	.....	.....	1	.....	.....	6
25	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	.....	.....	2
25	.....	.....	2	1	2	1	1	1	.....	.....	.....	1	.....	9
25	.....	.....	21	9	18	10	9	3	8	3	2	.....	.....	83
25	.....	.....	3	1	2	1	.....	1	4	1	.....	.....	.....	13
25	.....	.....	.....	.....	.....	.....	1	.....	1	1	.....	.....	1	4
	.....	.....	55	44	32	26	25	29	33	12	10	4	3	273
Second brood:														
Aug. 1	13	3	6	3	3	5	4	14	40	29	24	5	2	151
1	6	1	6	4	5	4	9	24	63	40	58	21	7	218
	19	4	12	7	8	9	13	38	103	69	82	26	9	399
Total	19	4	67	51	41	70	52	71	137	84	93	30	12	731

BAND RECORDS OF 1913.

Band records were regarded as forming an important part of the life-history studies conducted throughout the season.

Besides the advantage offered in the opportunity to study the insect under natural conditions, the careful collection of accumulated larvæ from the bands at regular intervals serves to furnish valuable data on the relative abundance of the several broods of larvæ throughout the season, and provides in addition desirable material for laboratory rearing experiments.

During the season of 1913, band records were conducted at different points within the State in an endeavor to secure possible data on the life history and habits of the insect in more or less widely-separated localities which represented a variety of conditions.

In addition to the band-record experiments at Roswell, similar experiments were installed at Carlsbad, Artesia, Lincoln, and Santa Fe. At Carlsbad some difficulty was experienced in finding suitable trees for banding because of the scarcity of desirable trees of bearing age. Carlsbad and vicinity may be considered to represent one of the points of lowest altitude in New Mexico, and largely for this reason it was desired to install experiments there. Through the courtesy of Mr. Francis G. Tracy, however, five apple trees were set aside for this purpose.

No larvæ were reported found during May and only a total of 21 larvæ throughout the month of June. Partly on account of the prevailing scarcity of fruit on the trees used, no collections were made after July 1, and later the work in this locality was abandoned.

RESULTS AT ROSWELL.

Banded trees for the experiments at Roswell were selected about May 15, although no collections are recorded until May 20. Through the kindness of a number of orchard owners, trees for banding were obtained as follows: Five trees on the farm of Capt. W. C. Reid, 5 belonging to Mr. H. J. Hagerman; 4 in the orchard of Mr. R. C. Horner; and 3 in an orchard owned by Mr. Robert Beers. Careful collections were made from the bands on these trees at intervals of three days from May 20 until November 7, and an accurate record kept of the larvæ found. By consulting the figures in Table LIX it will be noted that the maximum number of first-brood larvæ occurring in the field is found to be on May 29, when 833 larvæ were

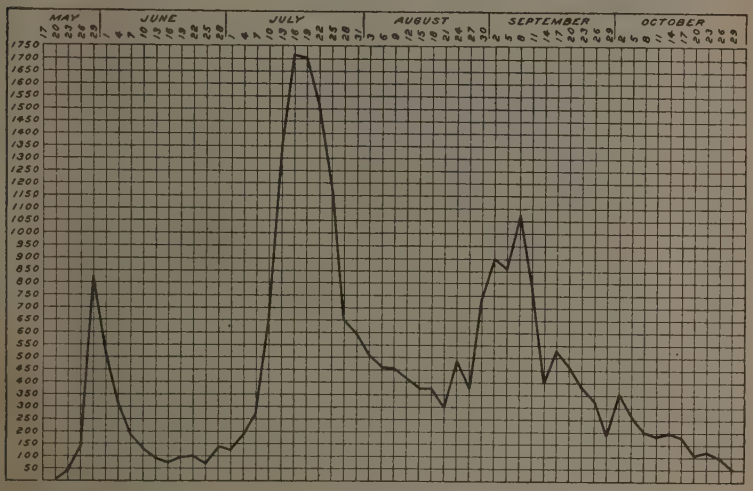

FIG. 11.—Curve showing occurrence of codling-moth larvæ under bands on apple trees, Roswell, N. Mex., 1913. (Original.)

collected from the 17 banded trees. Of this number, 129 proved to be wintering larvæ while 654 transformed and emerged as moths.

A second maximum is found to occur July 16, when 1,674 larvæ were collected from the bands. Of this number 339 proved to be wintering larvæ, and 1,318 transformed the same season.

The greatest number of third-brood larvæ collected on a specified date occurred September 8, when 1,073 are recorded. The number of larvæ wintering at this time in the season is much greater, a total of 1,062 being found, while only 3 larvæ transformed and emerged the same season. Because of the overlapping of the broods of larvæ late in the season, this condition renders it impossible to determine from these data when fourth-brood larvæ occurred in greatest numbers in the field. (See fig. 11.)

TABLE LIX.—*Codling-moth larvæ from bands and emergence of moths, Roswell, N. Mex., 1913.*

Observation No.	Date of collection.	Number of larvæ.	Emergence of moths.	Number of wintering larvæ.	Observation No.	Date of collection.	Number of larvæ.	Emergence of moths.	Number of wintering larvæ.
1	May 20	5	3	1	30	15	375	118	255
2	23	40	39	1	31	18	367	110	253
3	26	140	139	1	32	21	295	82	213
4	29	833	654	129	33	24	484	67	412
5	June 1	517	463	54	34	27	378	19	357
6	4	320	274	46	35	30	730	11	719
7	7	249	150	99	36	Sept. 2	900	4	896
8	10	130	113	17	37	5	858	.....	858
9	13	89	82	7	38	8	1,073	3	1,062
10	16	76	70	6	39	11	815	.....	805
11	19	95	77	18	40	14	395	.....	386
12	22	94	88	6	41	17	533	1	527
13	25	69	68	1	42	20	465	.....	465
14	28	140	128	11	43	23	381	.....	381
15	July 1	127	112	14	44	26	330	.....	330
16	4	183	153	30	45	29	174	.....	174
17	7	274	251	22	46	Oct. 2	354	.....	354
18	10	654	548	94	47	5	265	.....	265
19	13	1,335	1,060	275	48	8	205	.....	205
20	16	1,674	1,318	339	49	11	182	.....	182
21	19	1,667	1,324	350	50	14	192	.....	192
22	22	1,510	1,258	248	51	17	180	.....	180
23	25	1,166	969	197	52	20	107	.....	107
24	28	652	548	99	53	23	119	.....	119
25	31	618	454	176	54	26	100	.....	100
26	Aug. 3	510	300	206	55	29	51	.....	51
27	6	463	238	223	56	Nov. 1	.....	.....	.....
28	9	458	174	284	57	4	.....	.....	.....
29	12	432	154	277	58	7	65	.....	65

RESULTS AT ARTESIA.

The results from the band records at Artesia proved much more satisfactory than did those at Carlsbad, and some valuable data were obtained.

The experiments were installed somewhat later in the season than were those at Roswell, and in consequence the first collection of larvæ was not made until June 4, on which date 33 larvæ were found. This date may be considered too late in the season to serve in determining the occurrence at this place of the maximum number of first-brood larvæ to contrast with May 29, the date when the greatest number occurred at Roswell.

On July 10, however, 719 larvæ were taken from the bands and represent the maximum number for second-brood larvæ. This occurred just six days earlier in the season than did the corresponding stage at Roswell.

From the figures at hand relative to the greatest number of larvæ to be found in the field at the time of the first collection in September, no maximum number can be described, but from previous conclusions drawn from contrasts with corresponding stages at Roswell, it would appear that the greatest number of third-brood larvæ would be found about September 2.

Regular collections were made on specified dates throughout the season corresponding with the collections made at Roswell and continuing until September 17, when the records were discontinued. The records of these collections are more fully shown in Table LX.

TABLE LX.—*Band records at Artesia, N. Mex., 1913.*

[Larvæ collected by Mr. N. E. Brainard.]

Record No.	Date of collection.	Number of larvæ.	Emergence of moth.	Wintering larvæ.	Record No.	Date of collection.	Number of larvæ.	Emergence of moth.	Wintering larvæ.
6	June 4	33	20	13	24	28	284	194	90
7	7	50	27	23	25	31	179	128	51
8	10	24	21	3	26	Aug. 3	123	72	51
9	13	10	8	2	27	6	113	35	78
10	16	48	31	17	28	9	55	27	28
11	19	44	39	5	29	12	56	19	37
12	22	43	30	13	30	15	73	28	45
13	25	61	42	19	31	18	42	16	26
14	28	119	56	63	32	21	50	9	43
15	July 1	99	66	33	33	24	47	2	45
16	4	345	181	164	34	27	29	3	26
17	7	542	293	249	35	30	21	.....	21
18	10	719	530	189	36	Sept. 2	19	.....	19
19	13	643	406	237	37	5	24	.....	24
20	16	570	431	139	38	8	10	.....	10
21	19	423	342	81	39	11	14	.....	14
22	22	278	207	61	40	14	3	.....	3
23	25	420	261	159	41	17	7	.....	7

Figure 12 represents graphically the results of band records at Artesia, and in addition shows the probable time of occurrence in

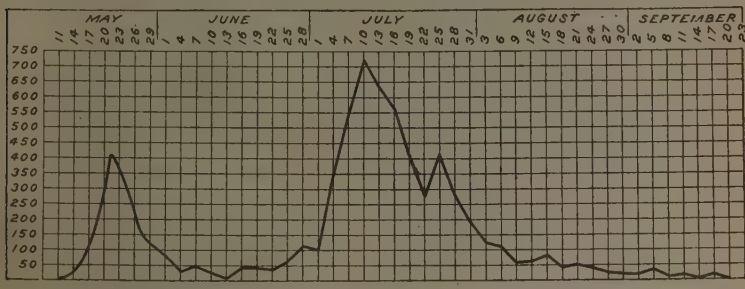

FIG. 12.—Curve showing codling-moth larvæ under bands on apple trees, Artesia, N. Mex., 1913. (Original.)

the field of larvæ of the first brood. While this feature is of a more or less speculative nature, it may be regarded as being in close accordance with facts.

RESULTS AT LINCOLN.

Lincoln is located 65 miles west of Roswell, between El Capitan Mountain and Sierra Blanca peak, a northerly spur of the Sacramento Mountains, and has an altitude of some 5,700 feet. Through the courtesy of Dr. J. W. Laws a number of bearing apple trees were set aside for use in banding, and these furnished larvæ throughout the season. While the bands were placed on the trees early in May, no larvæ were found until June 13. Despite the fact that larvæ occurred more or less intermittently from that date until the season closed, November 7, it would appear that only two full broods and a partial third are found in the higher fruit-growing regions.

The records found in Table LXI show that the maximum number of larvæ of the first brood of that season were found beneath the

bands July 13. The greatest number of second-brood larvæ occurred August 30, 48 days later, and the very probable overlapping of this brood with larvæ of the partial third brood, coupled with a decreasing amount of available fruit during the late summer and early fall,

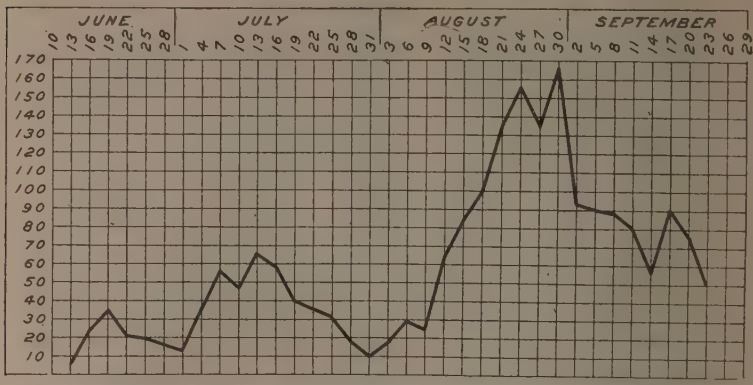

FIG. 13.—Curve showing occurrence of codling-moth larvæ under bands on apple trees. Lincoln, N. Mex., 1913. (Original.)

undoubtedly was influential in producing a uniform number of larvæ from which no reliable maximum number could be determined.

TABLE LXI.—*Codling-moth larvæ from bands and emergence of moths, Lincoln, N. Mex., 1913.*

[Larvæ collected by Mr. E. A. Engstrom.]

Record No	Date of collection.	Number of larvæ.	Emergence of moths.	Number of wintering larvæ.	Record No.	Date of collection.	Number of larvæ.	Emergence of moths.	Number of wintering larvæ.
1	May 20				30	Aug. 15	84	35	49
2	23				31	18	100	26	74
3	26				32	21	134	24	110
4	29				33	24	156	6	150
5	June 1				34	27	134	2	132
6	4				35	30	167	1	166
7	7				36	Sept. 2	93		93
8	10				37	5	89		89
9	13	7	6	1	38	8	88	1	87
10	16	25	18	7	39	11	71		71
11	19	35	29	6	40	14	56		56
12	22	20	13	7	41	17	89		89
13	25	20	18	2	42	20	78		78
14	28	17	14	3	43	23	50		50
15	July 1	14	14		44	26	34		34
16	4	36	31	5	45	29	20		20
17	7	56	42	10	46	Oct. 2	28		28
18	10	46	40	6	47	5	30		30
19	13	67	50	17	48	8	26		26
20	16	60	50	10	49	11	32		32
21	19	41	24	17	50	14	40		40
22	22	37	31	6	51	17	29		29
23	25	32	23	9	52	20	12		12
24	28	17	12	5	53	23	7		7
25	31	10	8	2	54	26	23		23
26	Aug. 3	17	9	8	55	29	1		1
27	6	30	20	10	56	Nov. 1	6		6
28	9	25	11	14	57	4	14		14
29	12	61	22	[illegible]	58	7	15		15

The band-record curve found in figure 13 is intended to show in a general way the fluctuating occurrence of larvæ in the region of Lincoln, and in addition to illustrate the periods when greatest numbers of larvæ may probably be present.

While the figures in Table LXI give the number of moths emerging from each specific collection, no dates corresponding to these emergences are included. Reference to figure 14 will, however, furnish data showing the number of moths emerging on specified days from June 26 until September 20, after which date the adults failed to appear. The somewhat exceptional fluctuating feature of the emergences is here graphically illustrated.

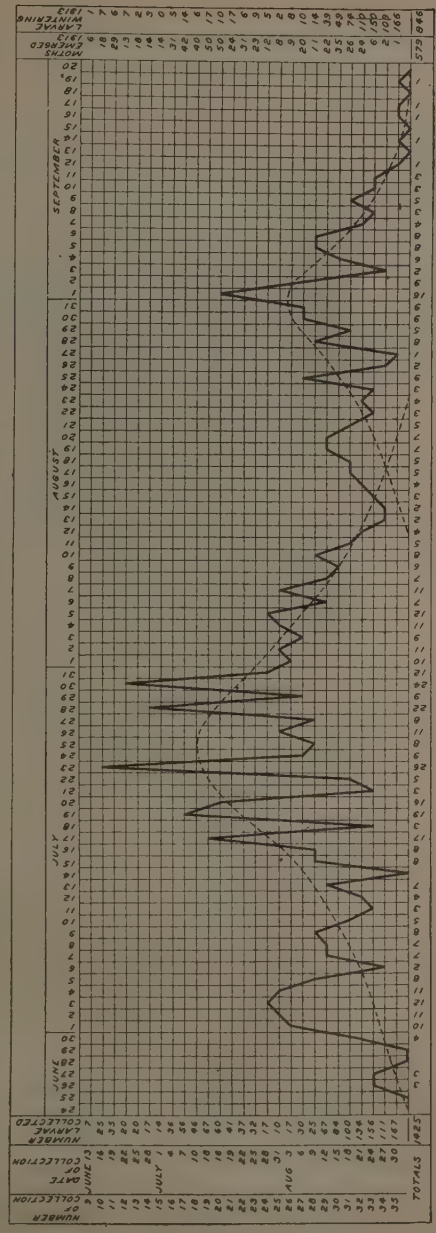

FIG. 14.—Curve showing emergence of codling moths from band-record larvæ at Lincoln, N. Mex., 1913. (Original.)

RESULTS AT SANTA FE.

Santa Fe is located somewhat north of the geographical center of New Mexico, at an altitude of about 7,000 feet. While commercial fruit growing has never been conducted here on as extensive a scale as in many other parts of the State, the section has long been settled and the growing of fruit has been practiced

for many years. Because of the rather exceptionally high altitude and its possible effect on insect behavior, it was considered desirable to make band records in this mountain locality.

Through the courtesy of Dr. James Rolls, a number of trees were obtained for this purpose, and bands placed on them in May. However, no larvæ were found until June 7, when 5 were taken from the bands, 4 of which proved to be wintering larvæ. The maximum number of larvæ of the first brood occurred July 16, the exact date of the occurrence of the greatest number of larvæ of the second brood at Roswell. From this date on the number collected is so variable that no very definite conclusions can be drawn. However, it appears probable that the overlapping of first-brood larvæ with a partial second brood may have taken place about September 5. Reference to Table LXII will show the great number of wintering larvæ after August 1 and the number of moths emerging from band-record larvæ throughout the season.

TABLE LXII.—*Band records for the codling moth at Santa Fe, N. Mex., 1913.*

[Larvæ collected by Mr. Alfred Rolls.]

Record No.	Date of collection.	Number of larvæ.	Emergence of moths.	Wintering larvæ.	Record No.	Date of collection.	Number of larvæ.	Emergence of moths.	Wintering larvæ.
7	June 7	5	1	4	33	Aug. 24	15	.....	15
8	10	.....	.....	.....	34	27	26	.....	26
9	13	.....	.....	.....	35	30	19	.....	19
10	16	1	.....	1	36	Sept. 2	20	.....	20
11	19	2	.....	2	37	5	22	.....	22
12	22	4	2	2	38	8	16	.....	16
13	25	.....	.....	.....	39	11	11	.....	11
14	28	2	.....	2	40	14	7	.....	7
15	July 1	.....	.....	.....	41	17	6	.....	6
16	4	1	.....	1	42	20	17	.....	17
17	7	3	3	.....	43	23	9	.....	9
18	10	10	8	2	44	26	.....	.....	.....
19	13	21	12	9	45	29	4	.....	4
20	16	38	28	10	46	Oct. 2	13	.....	13
21	19	23	14	9	47	5	7	.....	7
22	22	24	7	17	48	8	12	.....	12
23	25	28	8	20	49	11	11	.....	11
24	28	19	4	15	50	14	8	.....	8
25	31	25	.....	25	51	17	8	.....	8
26	Aug. 3	19	.....	19	52	20	6	.....	6
27	6	35	1	.....	53	23	6	.....	6
28	9	34	.....	.....	54	26	.....	.....	.....
29	12	37	.....	37	55	29	.....	.....	.....
30	15	25	.....	25	56	Nov. 1	.....	.....	.....
31	18	36	.....	36	57	4	.....	.....	.....
32	21	31	.....	31	58	7	1	.....	1

In figure 15 may be seen a diagram illustrating the variable manner in which the larvæ were found to occur in the field at Santa Fe during the season of 1913. While it is difficult to account for this evident variation, weather conditions prevailing at times during the period of observations very probably influenced the number of larvæ materially.

The emergence of moths from band-record larvæ at Santa Fe was more or less regular, according to the curve found in figure 16, as contrasted with the corresponding illustration dealing with the emer-

gence of moths from band-record larvæ collected at Lincoln the same season. From a total of 260 larvæ removed from the bands at Santa Fe, 169 larvæ, or 65 per cent, proved to be wintering larvæ, and 88 of the entire number transformed the same season to emerge as moths.

SEASONAL HISTORY OF THE CODLING MOTH DURING 1913.

Figure 17 illustrates graphically the seasonal history of the codling moth during 1913 with dates of the respective broods and genera-

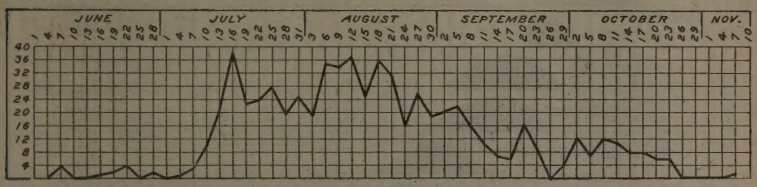

FIG. 15.—Curve showing occurrence of codling-moth larvæ under bands on apple trees, Santa Fe, N. Mex., 1913. (Original.)

tions. As in the case of figure 4, illustrating the seasonal history for 1912, the periods indicated by these diagrams are averaged or generalized, and the tables giving actual dates of occurrence should be consulted when specific information is wanted. Both of the seasonal-history charts are made on the same plan and the description of figure 4 on pages 31–32 will apply alike to both of the illustrations.

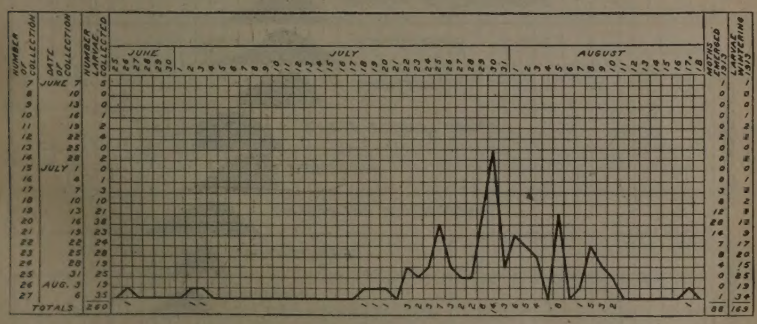

FIG. 16.—Curve showing occurrence of codling-moth larvæ under bands on apple trees, Santa Fe, N. Mex., 1913. (Original.)

SUMMARY.

In the Pecos Valley of New Mexico the codling moth produced during 1912 three complete generations. In 1913 a partial fourth brood of larvæ developed, and it is considered probable that this is of normal occurrence.

Pupation of overwintering larvæ in 1912 began March 15 and continued for about one month. In 1913 the first pupa was noticed March 23 and pupation continued for 51 days.

Moths of the spring brood in 1912 were first in evidence April 12 and continued to emerge to May 28. In 1913 the spring brood of moths was out from April to early June.

Female moths of the spring brood in 1912 lived on the average 8.47 days and in 1913, 12.88 days. Male moths in 1912 lived 6.7 days.

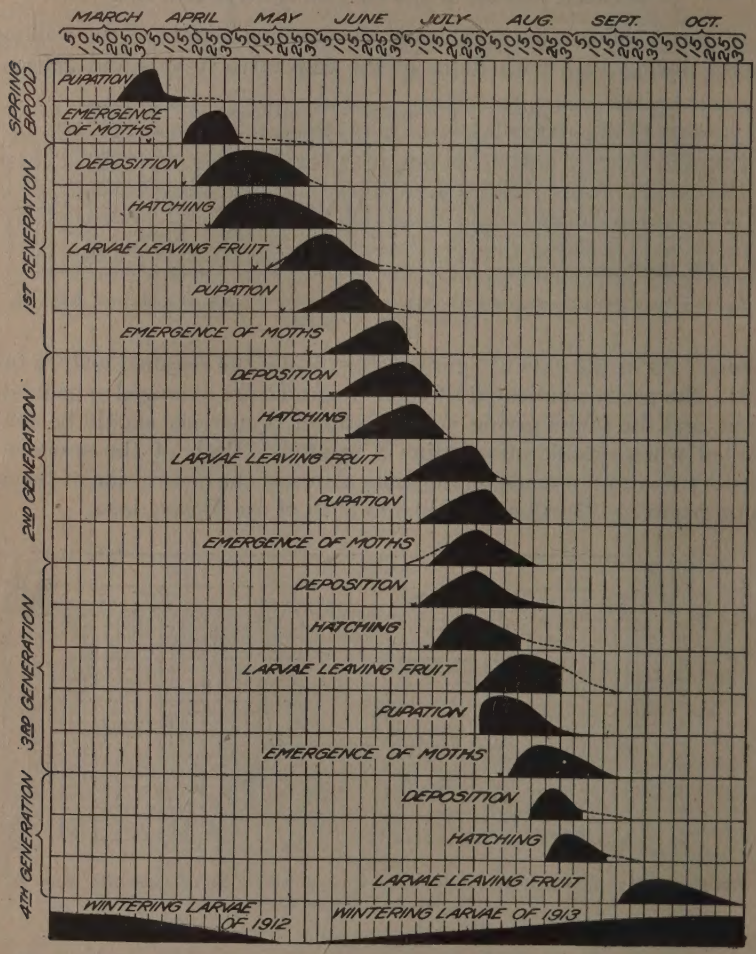

FIG. 17.—Diagram showing the seasonal history of the codling moth at Roswell, N. Mex., in 1913. (Original.)

In 1912 oviposition of the spring brood of moths began April 16, continuing 45 days, while in 1913 first eggs of this brood were noted May 1. The time required for first-brood eggs to hatch in 1912 was 9.05 days, with a range of 5 to 13 days, whereas in 1913 eggs of this brood hatched on an average in 5.96 days, with a range of from 4 to 11 days.

First-brood larvæ in 1912 fed on an average 21.52 days, and in 1913, 24.45 days.

The pupal stage of the first brood in 1912 averaged 12 days, and in 1913, 11 days.

Moths of the first brood in 1912 were out June 9 and continued to emerge until July 22. In 1913 first moths were out June 3, the period of emergence lasting until July 10.

First-brood moths in 1912 oviposited over an average period of 4.45 days, and in 1913, 5.7.

The life cycle of the first generation in 1912 required on the average 51.14 days, and in 1913, 46.91 days.

Second-brood eggs in 1912 averaged 5.62 days for incubation, with a minimum of 4, and a maximum of 8 days. The incubation period of eggs of this brood in 1913 was on the average 4.9, with a minimum of 4 and a maximum of 7 days.

The feeding period of second-brood larvæ in 1912 averaged 21.23 days, and in 1913, 19.7 days.

The pupal stage for second-brood pupæ in 1912 averaged 11.23 days, and in 1913, 11.06 days.

The life cycle for the second generation of the codling moth in 1912 averaged 41.26 days, and in 1913, 41.04 days.

Eggs of the third brood in 1912 averaged 5.75 days for the incubation period, with a minimum of 4 and a maximum of 9 days. In 1913 the incubation period for eggs of this brood averaged 5.36 days.

During 1912 third-brood larvæ fed on an average of 26.55 days with a range of from 15 to 56 days, whereas in 1913 the average feeding period for this brood was 20 days, the range being from 15 to 28 days.

The pupal stage of the third brood in 1912 required on an average 14.94 days, with a minimum of 11 and a maximum of 20 days. The average length of this stage in 1913 was 11.4 days, with a minimum of 7 and a maximum of 17 days.

The life cycle of the third generation of 1912 required on an average 48.57 days, with a range of from 36 to 62 days, and in 1912, 43 days, with a range of 34 to 58 days.

Fourth-brood eggs were in evidence in 1913 on August 20, and oviposition continued to September 8. The incubation period, on an average, was 7.9 days.

The feeding period of fourth-brood larvæ in 1913 averaged 38.36 days, with a minimum of 25 days and a maximum of 53 days. All of these larvæ passed the winter as such.

Records of egg deposition by individual moths were obtained with females of the spring brood and also of the first and second broods. The maximum egg deposition by a female of the spring brood in 1912 was 91 eggs, while the average number per moth was approximately 28 eggs.

The highest oviposition record established was by a female of the second brood in 1913, with a total of 259 eggs.

Oviposition may occur two days after the emergence of moths, and, on an average, moths of the first brood in 1913 continued oviposition over a period of 5.7 days.

The average incubation period for all eggs of the four generations produced during 1913 was 6.4 days. The corresponding average for the three generations during the season of 1912 was 6.8 days.

Studies in the insectary of the hourly emergence of moths show that of 788 records of individuals the greatest number, 17.44 per per cent, emerged at 3 p. m. In general the maximum period of emergence was found to occur at the time of, or almost immediately following, the period of highest temperature for the day. There was some variation from this, however, earlier in the season.

Fourth-brood larvæ were found leaving the fruit on September 23, after a feeding period of 28 days. Larvæ of this brood persisted as late as October 21 in the rearing shelter, and the last collection from bands in orchards showed larvæ to be present as late as November 1.

The wintering larvæ of 1913, as illustrated in figure 17, were composed of 7.16 per cent of the larvæ of the first brood; of 19.98 per cent of the larvæ of the second brood; of 75.06 per cent of larvæ of the third brood; and of 100 per cent of the fourth brood.

The feeding period of wintering larvæ of the first brood in 1913 was 0.68 day longer than the corresponding period for the transforming larvæ of the same brood. Wintering larvæ of the second brood fed 1.94 days longer than transforming larvæ of this brood, while the length of feeding period of wintering larvæ of the third brood exceeded that of the transforming larvæ by 1.1 days.

The probable effect of sudden changes of temperature on the activities of the codling moth is illustrated in figure 8. Temperature records also accompany figure 1.

Successful band records were made during 1913 at Roswell, Artesia, Lincoln, and Santa Fe. From available data the conclusion is drawn that at Lincoln there occur two full generations and a partial third, while at Santa Fe, a more northerly location, there appears to be but one complete generation, followed by a partial second.

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